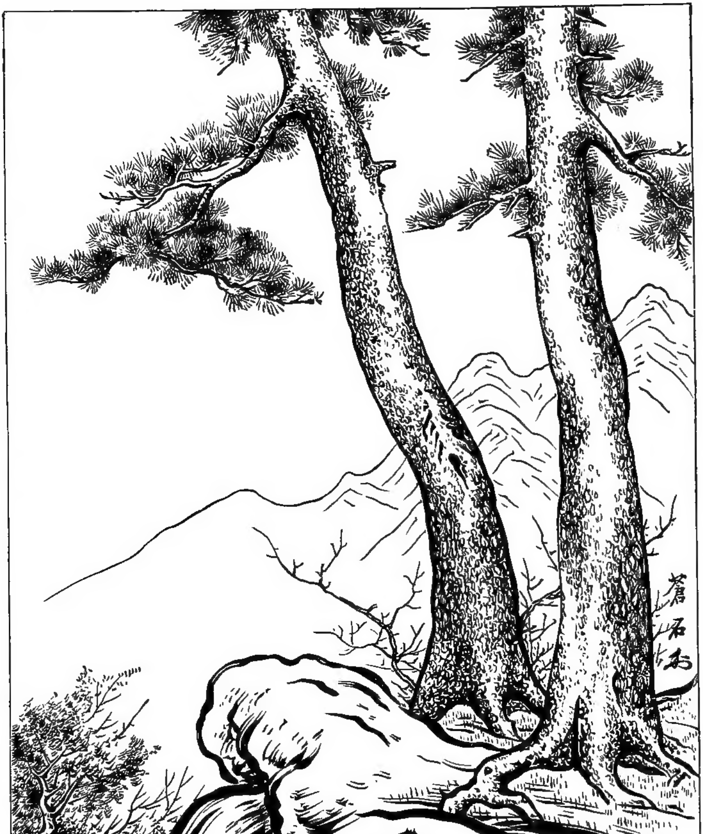

FIG. 1.—Akamatsu *(Pinus densiflora)*.

AN ELEMENTARY TEXT-BOOK OF BOTANY,

FOR THE USE OF JAPANESE STUDENTS.

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TOKYO:
XXVIth YEAR OF MEIJI (1893).

PREFACE.

The science of Botany, like that of other branches of Natural History, has two aspects: in one as a science of classification; and in the other as a science of observation, experiment, and induction. Not only are observation, experiment, and induction important processes in early education, but also to learn to classify is in itself an education. Moreover there is a great mass of useful knowledge embodied in Botany. The study of Botany, therefore, is an indispensable part of common education.

As we, in the first place, have aimed at rendering more effectual the lessons of Botany as a science of classification, applied to education, we had prepared this volume thoroughly on the logical system of classification, which embraces an enormous detail of subjects. In this volume, therefore, all facts and theories are arranged in one circle of system, without being separately treated, but exhibiting both their natural orders and relationships with each other.

We have wanted moreover to obtain the greatest effect of Botany as a science of experiment and induction, applied to education; consequently all explanations are accompanied by experiments and inductive generalization.

We have also taken care that, a fact should always precede its explanation, because the name is only an expression of a fact or idea. Failing to find suitable terms in many cases, we have selected them originally, and con-

structed them, in a definite manner, from terms that always exist, although it was necessary sometimes to use two or more words, and thus the terms constructed have become long ones. There is a logical relation between a fact and its term, and the students may be taught this very easily.

We must express our thanks to Mr. J. N. Seymour for his kindness in correcting the manuscript.

TOKYO, FEBRUARY, XXVI TH YEAR OF MEIJI (1893).

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CHAPTER I.

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AN
ELEMENTARY TEXT BOOK
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GENERAL INTRODUCTION.

If such plants as the Mume *(Prunus Mume)*, Sakura *(Prunus pseudo-cerasus)* (Fig. 2), Daikon *(Raphanus sativus)* (Fig. 6), and Nadzuna *(Capsella bursa-pastoris)* (Fig. 5) are examined, it will be seen that their outward forms differ more or less one from another.

If sections of the several parts of these plants are observed under the microscope, it will be found that they are internally formed of different minute structures.

If the living processes of these plants are thoroughly investigated, it will be known that they enlarge and increase their parts and reproduce their kinds.

Lastly, if these plants are compared, it will be recognized that the Mume has a much greater resemblance to the Sakura (Fig. 2) than to the others, and that the Daikon (Fig. 6) has a closer resemblance to the Nadzuna (Fig. 5).

The science, which deals with every thing that has reference to plants as seen in the above mentioned investigations, is called *Botany*. That department of the science which treats of the outward forms of plants is called *Morphological Botany;* that department which comprises

the study of the internal structure of plants is called *Histological Botany ;* that department which investigates the living processes of plants is called *Physiological Botany ;* and that department which considers plants as to their kinds and relationships is called *Systematic Botany.*

FIG. 2.

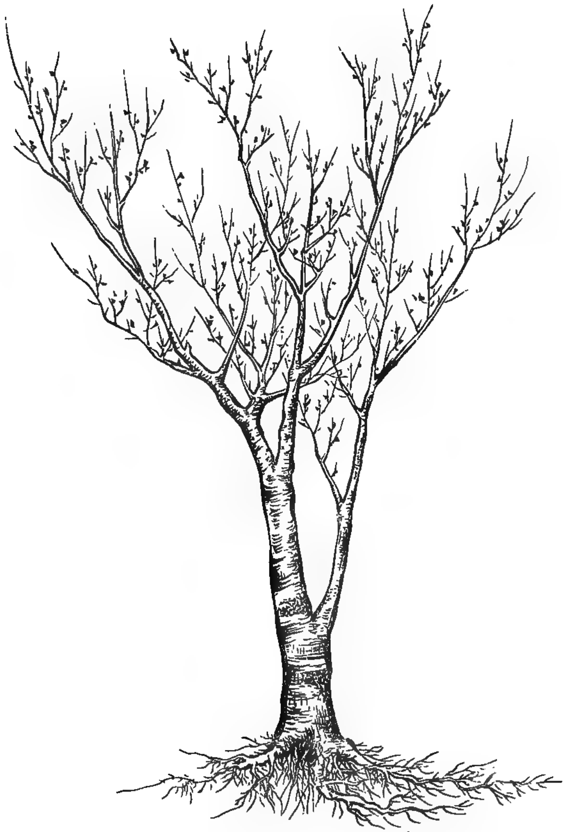

FIG. 2.—Sakura *(Prunus pseudo-cerasus).*

In Botany there are several other departments:—*Geographical Botany*, which treats of the distribution of plants over the surface of the earth at the present time; *Fossil Botany*, which considers the plants in a fossil state; and *Applied Botany*, which consists of the study of plants with special reference to various practical purposes.

BOOK I.

MORPHOLOGICAL BOTANY.

INTRODUCTION.

If all the parts of such highly developed plants as the Nadzuna (Fig. 5), Daidzu *(Glycine hispida)*, etc., are carefully observed by the unassisted eye, it will be seen that each plant consists of the axis, the upper portion of which is directed upwards and bears laterally green flat members, and the lower portion of which is directed downwards and does not bear those lateral appendages. That portion of the axis directed upwards and bearing green lateral members is called the *Stem;* that portion directed downwards and

FIG. 3.

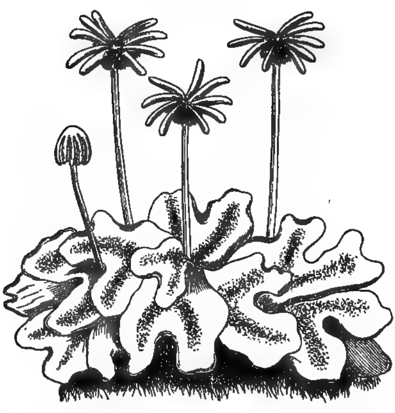

FIG. 3.—Zenigoke *(Marchantia polymorpha).*

not bearing those lateral appendages, the *Root ;* and the green flat lateral members or appendages on the stem, *Leaves.* Moreover small slender protuberances will be found on the surface of every part; these are called *Hairs* or *Trichomes.*

As seen in the preceding observations, most higher plants consist of four parts, namely, *Roots, Stems, Leaves, and Hairs ;* but such lower plants as the Zenigoke *(Marchantia polymorpha)* (Fig. 3), Matsudake *(Armillaria edodes)* (Fig. 4), Kombu *(Laminaria japonica)* (Fig. 146), etc., do not present any differentiation into root, stem, and leaf, and the body of these plants is called a *Thallus.*

FIG. 4.

FIG. 4.—Matsudake *(Armillaria edodes).*

All the parts of the plant-body are represented in the following table.

PLANT-BODY	With differentiation	Root. Stem. Leaf. Hair.
	Without differentiation......	Thallus.

Fig. 5.

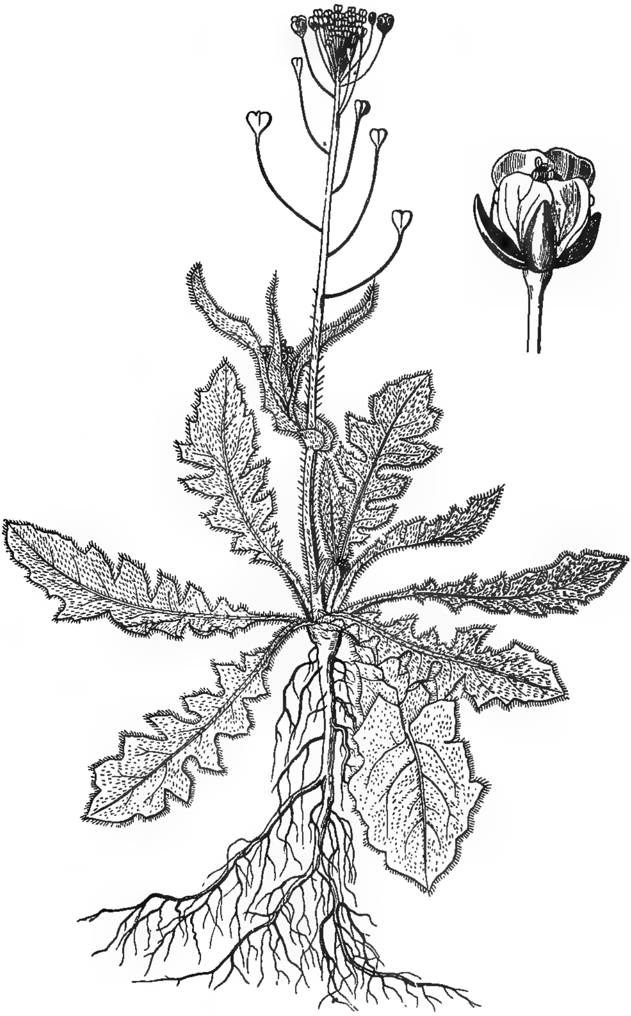

Fig. 5.—Nadzuna *(Capsella bursa-pastoris).*

CHAPTER I.

THE ROOT.

The Root is that part of the axis which never bears leaves; it usually grows downwards.

Section 1. PARTS OF THE ROOT.

The organically lower end of the root is called its *Base;* the opposite or organically upper end, its *Apex;* and the portion lying between the two extremities, its *Body.* (See Fig. 5.)

PARTS OF THE ROOT { Base. Body. Apex.

Section 2. TEXTURE OF ROOTS.

The texture of roots is either weak and delicate, as in the Daikon (Fig. 6), Ninjin *(Daucus carota)*, and Kabura *(Brassica campestris)*, or strong and hard, as in the Mume, Akamatsu *(Pinus densiflora)*, and Sakura (Fig. 2). When weak and delicate the root is said to be *Herbaceous*, and when strong and hard it is said to be *Woody*.

TEXTURE OF ROOTS { Herbaceous. Woody.

FIG. 6.

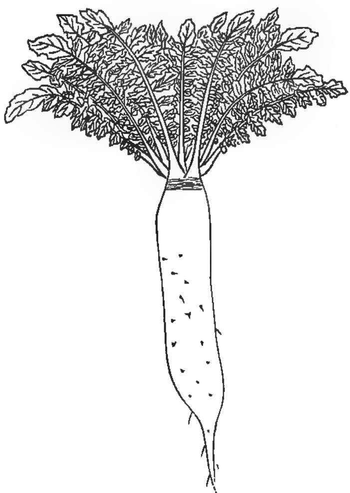

FIG. 6.—Daikon *(Raphanus sativus)*.

Section 3. DURATION OF ROOTS.

The duration of roots is various in different plants: some die the same year in which they are developed, as in the Asagao (*Ipomæa triloba)* (Fig. 9) and Kiuri (*Cucumis sativus);* some die the second year, as in the Daikon (Fig. 6) and Ninjin; and others live for many years, as in the Mume and Sakura (Fig. 2). Those which die the same year are said to be *Annual*; those which die the second year *Biennial;* and the others which live for many years *Perennial.*

$$\text{DURATION OF ROOTS}\begin{cases}\text{Annual.}\\ \text{Biennial.}\\ \text{Perennial.}\end{cases}$$

Section 4. KINDS OF ROOTS.

The root is various in reference to the medium in which it lives and the position from which it originates; hence it may be classified in two ways.

FIG. 7.

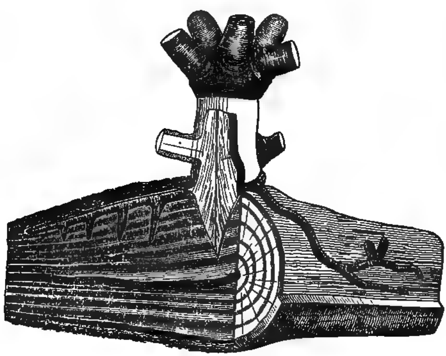

FIG. 7.—Parasitic root of the Yadoriki *(Viscum album).* (Sachs.)

1. *KINDS OF ROOTS IN REFERENCE TO THE MEDIUM.*

The root exists either penetrating into another plant, as in the Yadoriki *(Viscum album)* (Fig. 7) and Nenashi-kadzura *(Cuscuta japonica)*, or entirely free from another, as in the Mume and Sakura (Fig. 2); the former kind is called the *Parasitic Root*, and the latter the *Independent Root.*

KINDS OF ROOTS IN REFERENCE TO THE MEDIUM	Parasitic Root. Independent Root.

Of the independent roots, ordinary ones bury themselves in the soil, as in the Asagao (Fig. 9) and Sakura (Fig. 2), while some exist submersed in water, as in the Hishi *(Trapa bispinosa)* (Fig. 8) and Ukikusa *(Lemna minor)*,

FIG. 8.

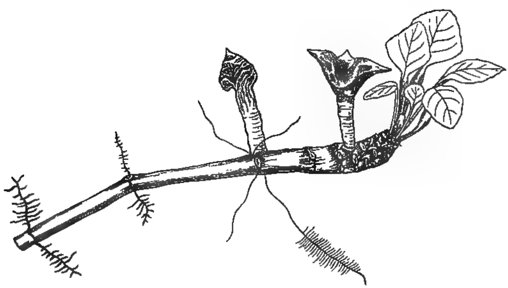

FIG. 8.—Hishi *(Trapa bispinosa)*, showing the aquatic roots and stem.

and others hang in the air, as in the Fūran *(Angræcum falcatum)* and Sekikoku *(Dendrobium moniliforme)*. Those burying themselves in the soil are called *Terrestrial Roots*, those existing in water *Aquatic Roots*, and those hanging in the air *Aerial Roots.*

INDEPENDENT ROOT	Terrestrial Root. Aquatic Root. Aerial Root.

Different kinds of roots in reference to the medium are represented in the following table.

KINDS OF ROOTS IN REFERENCE TO THE MEDIUM	Parasitic Root.	
	Independent Root	Terrestrial Root.
		Aquatic Root.
		Aerial Root.

2. *KINDS OF ROOTS IN REFERENCE TO THE POSITION.*

The root is developed either in the same straight line with the stem, or laterally on the other root, stem, or leaf. That which is developed in the same straight line with the stem is called the *Tap-root*, and the other which is developed laterally on the other root, stem, or leaf, is called the *Lateral Root*. (See Fig. 5.)

KINDS OF ROOTS IN REFERENCE TO THE POSITION	Tap-root.
	Lateral Root.

SUMMARY.

The *root* is that part of the axis which never bears leaves.

The *base* of the root is its organically lower end.

The *apex* of the root is its organically upper end.

The *body* of the root is the portion lying between the base and the apex.

The root is said to be *herbaceous* when its texture is weak and delicate.

The root is said to be *woody* when its texture is strong and hard.

The root is said to be *annual* when it dies the same year in which it is developed.

The root is said to be *biennial* when it dies the second year.

The root is said to be *perennial* when it lives for many years.

The *parasitic root* is one which penetrates into another plant.

The *independent root* is one which exists entirely free from any other plant.

The *terrestrial root* is one which buries itself in the soil.

The *aquatic root* is one which exists in water.

The *aerial root* is one which hangs in the air.

The *tap-root* is one which is developed in the same straight line with the stem.

The *lateral root* is one which is developed laterally on the other root, stem, or leaf.

CHAPTER II.

THE STEM.

The Stem is that part of the axis which always bears leaves; it usually grows upwards.

Section 1. PARTS OF THE STEM.

The organically lower end of the stem is called its *Base;*

FIG. 9.

FIG. 9.—Asagao (*Ipomœa triloba*).

the opposite or organically upper end, its *Apex;* the portion lying between the two extremities, its *Body;* the portion where leaves are borne, a *Node;* and the interval between two nodes, an *Internode.* (See Fig. 9.)

PARTS OF THE STEM
- Base.
- Body
  - Nodes.
  - Internodes.
- Apex.

Section 2. TEXTURE OF STEMS.

The texture of stems is also either weak and delicate, as in the Asagao (Fig. 9) and Nadzuna (Fig. 5), or strong and hard, as in the Akamatsu (Fig. 1) and Sakura (Fig. 2); when weak and delicate, the stem is said to be *Herbaceous*, and when strong and hard, it is said to be *Woody*.

TEXTURE OF STEMS
- Herbaceous.
- Woody.

Section 3. DURATION OF STEMS.

The duration of stems is also various in different plants: some die the same year in which they are developed, as in the Asagao (Fig. 9) and Kiuri; some die the second year, as in the Daikon (Fig. 6) and Ninjin; and others live for many years, as in the Akamatsu (Fig. 1) and Sakura (Fig. 2). Those which die the same year are said to be *Annual;* those which die the second year *Biennial;* and the others which live for many years *Perennial.*

DURATION OF STEMS
- Annual.
- Biennial.
- Perennial.

Section 4. KINDS OF STEMS.

The stem is also various according to the medium in which it lives and the position from which it originates, so that it may be classified in two ways.

1. *KINDS OF STEMS IN REFERENCE TO THE MEDIUM.*

The stem may exist either exposed to the air, as in the Mume and Sakura (Fig. 2), or buried in the soil, as in the Satoimo *(Colocasia antiquorum)* (Fig. 13) and Ayame *(Iris sibirica)*, or submersed in water, as in the Sasamo *(Potamogeton oxyphyllus)* and Hishi (Fig. 8). That which exists exposed to the air is called the *Aerial Stem;* that which exists buried in the soil, the *Subterranean Stem;* and that which exists submersed in water, the *Aquatic Stem.*

KINDS OF STEMS IN REFERENCE TO THE MEDIUM
- Aerial Stem.
- Subterranean Stem.
- Aquatic Stem.

The aerial stem may be either *Herbaceous*, as in the Asagao (Fig. 9) and Nadzuna (Fig. 5), or *Woody*, as in the Mume and Sakura (Fig. 2). Plants having herbaceous stems are called *Herbs*, and those having well developed woody stems *Trees.* Trees are all perennial, but herbs are very various, being annual, biennial, or sometimes perennial. In trees both roots and stems are perennial, while in perennial herbs the underground portions only survive, all the parts above ground usually dying after once fruiting.

AERIAL STEM
- Herbaceous Stem.
- Woody Stem.

Among herbaceous stems, some can raise themselves up without any support, as in the Ine *(Oryza sativa)* (Fig. 10) and Nadzuna (Fig. 5), while others can only raise themselves up by means of supports, as in the Asagao (Fig. 9) and Shiode (Smilax herbacea) (Fig. 52); the former are called *Independent Herbaceous Stems*, and the latter *Dependent* or *Climbing Herbaceous Stems.*

HERBACEOUS STEM { Independent Herbaceous Stem. / Dependent Herbaceous Stem. }

FIG. 10.

FIG. 10.—Ine *(Oryza sativa)*.

Among woody stems also, some can raise themselves up without any support, as in the Akamatsu (Fig. 1) and Sakura (Fig. 2), while others can only raise themselves up by means of supports, as in the Budō *(Vitis vinifera)* (Fig. 15) and Kidzuta *(Hedera Helix)*; the former are called *Independent Woody Stems*, and the latter *Dependent* or *Climbing Woody Stems*.

WOODY STEM { Independent Woody Stem. / Dependent Woody Stem. }

The subterranean stem exists buried in the soil and very much resembles the root, but it is easily distinguished from the latter, by the presence of either leaves, or leaf-scars.

Among subterranean stems, some are long and closely resemble roots, as in the Hakuka *(Mentha arvensis)* and

FIG. 11.

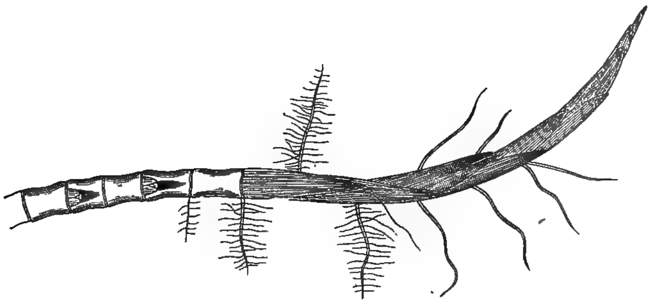

FIG. 11.—Rhizome of the Take *(Bambusa)*.

FIG. 12.

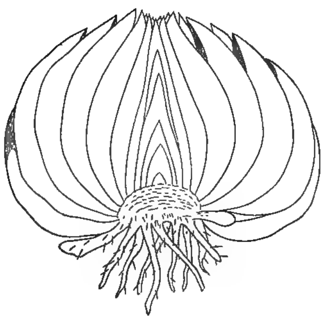

FIG. 12.—Bulb of the Oniyuri *(Lilium tigrinum)* with fleshy leaves.

Take *(Bambusa)* (Fig. 11); some are short and surrounded either by many fleshy leaves, as in the Oniyuri *(Lilium tigrinum)* (Fig. 12), or by only a few leaves more delicate,

as in the Satoimo (Fig. 13); and others are much thickened and fleshy, with usually very small leaves, as in the Jaga-

FIG. 13.

FIG. 13.—Bulb of the Satoimo *(Colocasia antiquorum)* with membranous leaves.

FIG. 14.

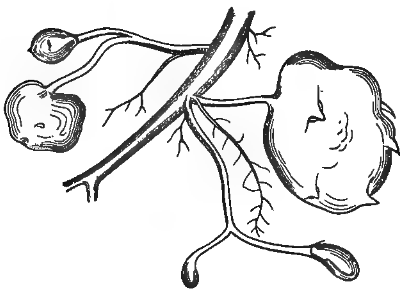

FIG. 14.—Tubers of the Jagataraimo *(Solanum tuberosum)* with minute subterranean leaves.

taraimo *(Solanum tuberosum)* (Fig. 14) and Kikuimo *(Helianthus tuberosus)*. Those which are long are called

Rhizomes; those which are short and surrounded by leaves, *Bulbs;* and the others which are much thickened and fleshy, with very small leaves, *Tubers.*

SUBTERRANEAN STEM $\begin{cases} \text{Rhizome.} \\ \text{Bulb.} \\ \text{Tuber.} \end{cases}$

FIG. 15.

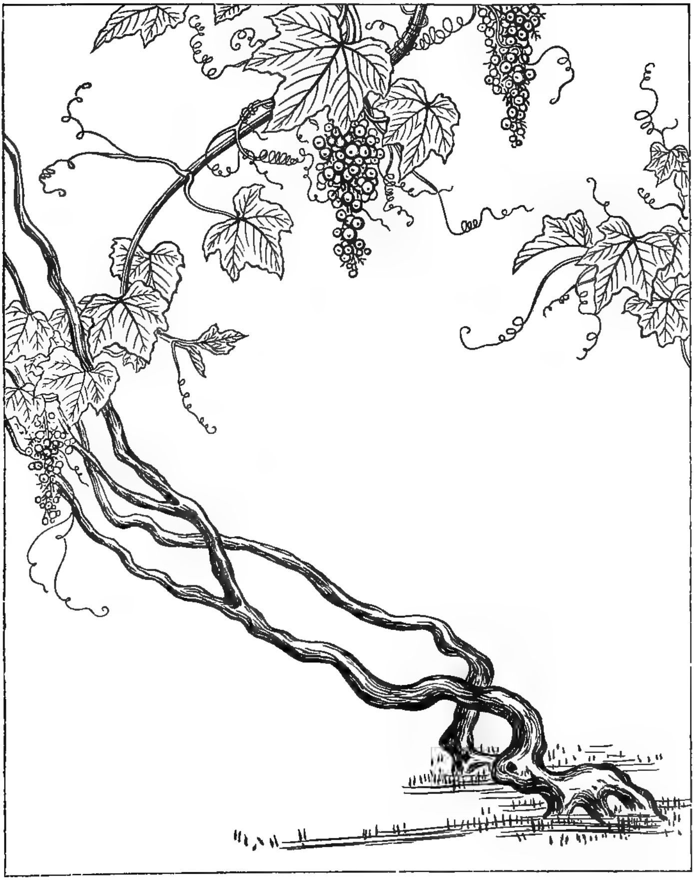

FIG. 15.—Budō *(Vitis vinifera).*

Different kinds of stems according to the medium are represented in the following table.

KINDS OF STEMS ACCORDING TO THE MEDIUM	Aerial Stem	Herbaceous Stem	Independent Herbaceous Stem.
			Dependent Herbaceous Stem.
		Woody Stem	Independent Woody Stem.
			Dependent Woody Stem.
	Subterranean Stem		Rhizome.
			Bulb.
			Tuber.
	Aquatic Stem.		

2. *KINDS OF STEMS IN REFERENCE TO THE POSITION.*

The stem is developed either as the main axis, which is sometimes connected and sometimes not connected with the tap-root, or laterally on the other stem, root, or leaf. That which is developed as the main axis is called the *Trunk* or *Main Stem*, and the other, which is developed laterally on the other stem, root, or leaf, is called the *Lateral stem* or *Branch*.

KINDS OF STEM IN REFERENCE TO THE POSITION	Main Stem.
	Lateral Stem.

SUMMARY.

The *stem* is that part of the axis which always bears leaves.

The *base* of the stem is its organically lower end.

The *apex* of the stem is its organically upper end.

The *body* of the stem is the portion lying between the base and the apex.

The *node* is that portion of the body of the stem where leaves are borne.

The *internode* is the interval between two nodes.

The stem is said to be *herbaceous* when its texture is weak and delicate.

The stem is said to be *woody* when its texture is strong and hard.

The stem is said to be *annual* when it dies the same year in which it is developed.

The stem is said to be *biennial* when it dies the second year.

The stem is said to be *perennial* when it lives for many years.

The *aerial stem* is one which exists exposed to the air.

The *subterranean stem* is one which exists buried in the soil.

The *aquatic stem* is one which exists submersed in water.

The *herb* is a plant having an herbaceous stem.

The *tree* is a plant having a woody stem.

The *independent herbaceous stem* is one which is herbaceous and can raise itself up without any support.

The *dependent herbaceous stem* is one which is herbaceous and can only raise itself up by means of supports.

The *independent woody stem* is one which is woody and can raise itself up without any support.

The *dependent woody stem* is one which is woody and can only raise itself up by means of supports.

The *rhizome* is a subterranean stem which is long and root-like.

The *bulb* is a subterranean stem which is short and surrounded by leaves.

The *tuber* is a subterranean stem which is thick and fleshy with very small leaves.

The *main stem* is one which is developed as the main axis which is sometimes connected and sometimes not connected with the tap-root.

The *lateral stem* is one which is developed laterally on the other stem, root, or leaf.

CHAPTER III.

THE LEAF.

The Leaf is always developed laterally on the stem and is usually of a flattened nature.

Section 1. PARTS OF THE LEAF.

The organically lower end of the leaf where it is attached to the stem is called its *Base;* the opposite or organically upper end, its *Apex;* and the portion lying between the two extremities, its *Body*. (See Fig. 16.)

PARTS OF THE LEAF { Base. Body. Apex.

Section 2. TEXTURE OF LEAVES.

The texture of leaves is either tough and leathery, as in the Tsubaki *(Camellia japonica)* and Yudzuriha *(Daphniphyllum macropodum)* (Fig. 25), weak and soft, as in the Sakura (Fig. 16) and Asagao (Fig. 9), thick and juicy, as in the Benkeisō *(Sedum alboroseum)* and in the bulbs of the Oniyuri (Fig. 12), or thin and flexible, as the underground leaves of the Negi *(Allium fistulosum)* and Satoimo (Fig. 13). When tough and leathery the leaf is said to be *Coriaceous;* when weak and soft it is said to be *Herbaceous;* when thick and juicy it is said to be *Succulent;* and when thin and flexible it is said to be *Membranous.*

TEXTURE OF LEAVES { Coriaceous. / Herbaceous. / Succulent. / Membranous.

Section 3. DURATION OF LEAVES.

The duration of leaves is also different in different cases: some die the same year in which they are developed, as in the Asagao (Fig. 9) and Sakura (Fig. 16); some die the second year, as in the Ninjin and Yudzuriha (Fig. 25); and others live for many years, as in the Asunaro *(Thuya dolabrata)* and Sugi *(Cryptomeria japonica)*. Those which die the same year are said to be *Annual;* those which die the second year *Biennial;* and the others which live for many years *Perennial.*

DURATION OF LEAVES { Annual. / Biennial. / Perennial.

Section 4. KINDS OF LEAVES.

The leaf is various according to the medium in which it lives and the function which it performs, so that it may be classified in two ways.

1. *KINDS OF LEAVES IN REFERENCE TO THE MEDIUM.*

The leaf may exist either exposed to the air, as in the ordinary case, or submersed in water, as in the Sasamo and Midzuōbako *(Ottelia japonica)*, or buried in the soil, as in the subterranean stems of the Oniyuri (Fig. 12) and Jagataraimo (Fig. 14).

That which exists exposed to the air is called the *Aerial Leaf;* that which exists submersed in water, the *Aquatic Leaf;* and that which exists buried in the soil, the *Subterranean Leaf.*

Kinds of leaves in reference to the medium	
	Aerial Leaf.
	Aquatic Leaf.
	Subterranean Leaf.

2. *KINDS OF LEAVES IN REFERENCE TO THE FUNCTION.*

Ordinary leaves are green, mostly flattened, and their functions are not related to reproduction. Such leaves are called *Foliage Leaves.* There are other leaves which have reproductive or protective functions, or which are insectivorous, or merely rudimentary, or varied in some other way. These are called *Modified Leaves.*

Kinds of leaves in reference to the function	
	Foliage Leaf.
	Modified Leaf.

A. THE FOLIAGE LEAF.

The Foliage Leaf is always green, mostly flattened, and does not produce reproductive organs; it has usually such two surfaces as one is turned upwards and the other downwards.

1. *PARTS OF THE FOLIAGE LEAF.*

In the most highly developed foliage leaf, its lower portion, including the base, is more or less dilated so as to embrace the stem, from which it springs; its upper portion, includ-

ing the apex, is usually expanded and flattened; and its middle portion is narrower and commonly semicylindrical. The expanded upper portion is called the *Lamina* or *Blade*,

FIG. 16.

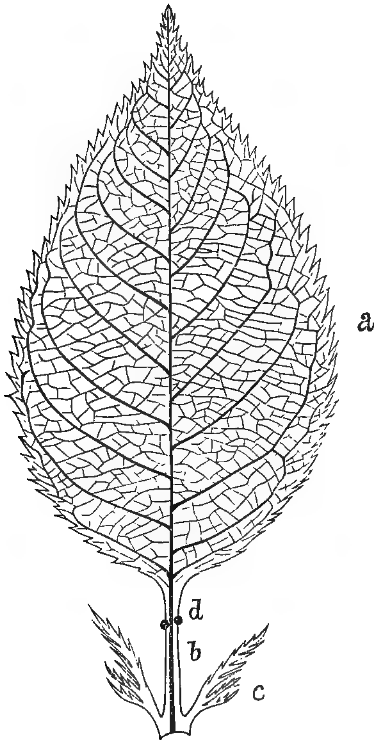

FIG. 16.—Herbaceous, annual, dentate, and pinnately veined leaf of the Sakura. a Lamina; b petiole; c leaf-sheath with stipules; d glands.

the narrower middle portion the *Petiole* or *Leaf-stalk*, and the sheath-like lower portion the *Leaf-sheath*. (See Fig. 16.) These three portions are not, however, developed in all leaves: in some leaves the leaf-sheath is absent as in those

of the Momiji *(Acer palmatum)* (Fig. 18); in some the petiole is absent as in those of the Ine (Fig. 10); and in others both the petiole and leaf-sheath are absent as in those of the Doku-utsugi *(Coriaria japonica)* (Fig. 19).

PARTS OF THE FOLIAGE LEAF { Lamina. / Petiole. / Leaf-sheath.

a. The Lamina.

The Lamina is the most important part of the foliage leaf and is usually expanded and flattened.

1. *PARTS OF THE LAMINA.*

The organically lower end of the lamina, where it is connected with the petiole in a well developed leaf, is called its *Base;* the opposite or organically upper end, its *Apex;* the lines connecting the two extremities, its *Margins;* and the portion enclosed within the margins, its *Body*. (See Fig. 16.)

PARTS OF THE LAMINA { Base. / Body—Margins. / Apex.

2. *VENATION OR NERVATION.*

The skeleton of the lamina is composed of woody thread-like structures which are called *Veins*, and the modes of their distribution are called *Venation.* Large veins, proceeding from the base to the apex of the lamina, are called *Ribs*, and the most prominent central vein is called the *Midrib.*

The veins are distributed either anastomosing so as to form a kind of network as in the leaves of the Sakura (Fig. 16) and Momiji (Fig. 18), or more or less parallel to one another as in the leaves of the Ine (Fig. 10) and Maidzurusō

(Maianthemum bifolium) (Fig. 17); when distributed as in the former case the venation is said to be *Reticulated-* or

FIG. 17.

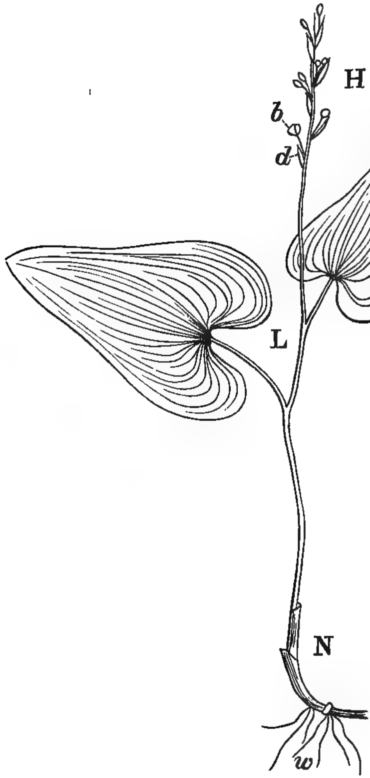

FIG. 17.—Maidzurusō *(Maianthemum bifolium)*.
H Portion of the stem with reproductive modified leaves; b flower; d scattered bract; L portion of the stem with foliage leaves; N portion of the stem with cataphyllary leaves; *w* roots. *(Prantl.)*

Netted-veined, and when distributed as in the latter it is said to be *Parallel-veined*.

VENATION { Netted-veined.
Parallel-veined.

Among netted-veined laminae, some have but one rib, as those of the Mume and Sakura (Fig. 16), while others more than one, as those of the Momiji (Fig. 18) and Yatsude

FIG. 18.

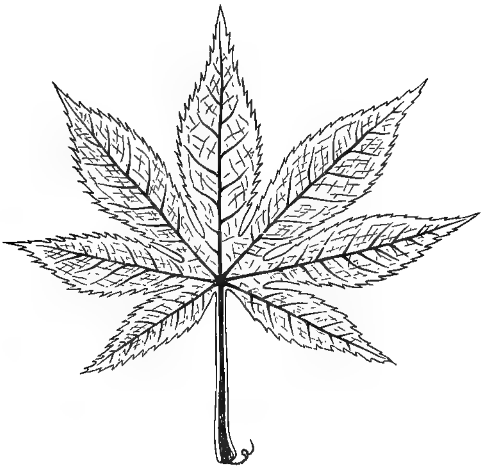

FIG. 18.—Divergipalmately veined and parted leaf of the Momiji *(Acer palmatum)*.

(Fatsia japonica); when one-ribbed the venation is said to be *Pinnately* or *Unicostately Veined*, and when several-ribbed *Palmately* or *Multicostately* Veined.

NETTED-VEINED { Pinnately Veined.
Palmately Veined.

Among palmately netted-veined laminae, some have diverging ribs, as those of the Momiji (Fig. 18) and Yatsude, and others converging ribs, as those of the Doku-utsugi (Fig. 19) and Ōbako *(Plantago asiatica)*; in the former case the venation is said to be *Divergipalmately Veined*, and in the latter it is said to be *Convergipalmately Veined*.

PALMATELY VEINED { Divergipalmately Veined. / Convergipalmately Veined. }

FIG. 19.

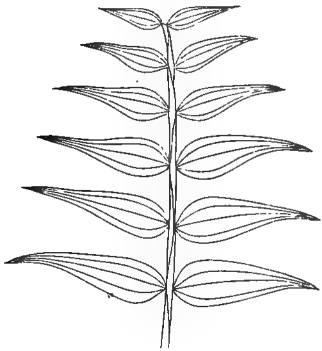

FIG. 19.—Shoot of the Doku-utsugi (*Coriaria japonica*) with convergipalmately veined leaves.

FIG. 20.

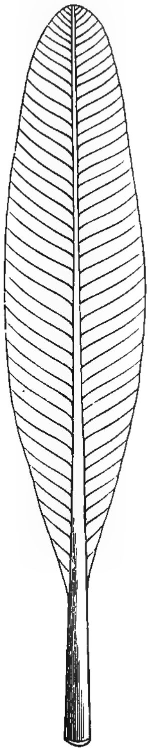

FIG. 20.—Costal-nerved leaf of the Bashō (*Musa Basjoo*).

FIG. 21.

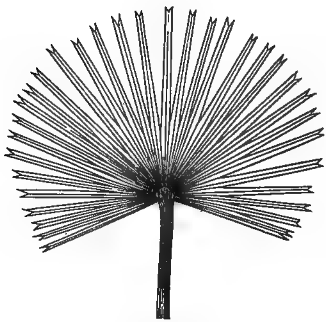

FIG. 21.—Flabellinerved leaf of the Shuro (*Trachycarpus excelsa*).

Among parallel-veined laminae also, some have but one rib, as those of the Bashō (*Musa Basjoo*) (Fig. 20) and Shōga (*Zingiber officinale*), while others more than one, as

those of the Maidzurusō (Fig. 17) and Shuro *(Trachycarpus excelsa)* (Fig. 21); when one-ribbed the venation is said to be *Costal-nerved*, and when several-ribbed *Basal-nerved.*

$$\text{PARALLEL-VEINED}\begin{cases}\text{Costal-nerved.}\\ \text{Basal-nerved.}\end{cases}$$

Among basal-nerved laminae also, some have diverging ribs, as those of the Shuro (Fig. 21) and Ichō *(Ginkgo biloba)*, and others converging ribs, as those of the Maidzurusō (Fig. 17) and Ine (Fig. 10); in the former case the venation is said to be *Flabellinerved*, and in the latter it is said to be *Longitudinal-nerved.*

$$\text{BASAL-NERVED}\begin{cases}\text{Flabellinerved.}\\ \text{Longitudinal-nerved.}\end{cases}$$

All the kinds of venation are represented in the following table.

$$\text{VENATION}\begin{cases}\text{Netted-veined}\begin{cases}\text{Pinnately Veined.}\\ \text{Palmately Veined}\begin{cases}\text{Divergipalmately Veined.}\\ \text{Convergipalmately Veined.}\end{cases}\end{cases}\\ \text{Parallel-veined}\begin{cases}\text{Costal-nerved.}\\ \text{Basal-nerved} \ldots\ldots \begin{cases}\text{Flabellinerved.}\\ \text{Longitudinal-nerved.}\end{cases}\end{cases}\end{cases}$$

3. *FORMS OF THE LAMINA.*

The lamina is mostly of such a form that it can be divided longitudinally into two similar halves side by side, as those of the Sakura (Fig. 16) and Bashō (Fig. 20), but in some cases the halves are not similar, as those of the Shūkaidō *(Begonia Evansiana)* (Fig. 22) and Nemu *(Albizzia Julibrissin)*; when the halves are similar the lamina is said to be *Symmetrical*, and when they are not similar *Unsymmetrical.*

$$\text{FORMS OF THE LAMINA}\begin{cases}\text{Symmetrical.}\\ \text{Unsymmetrical.}\end{cases}$$

Among symmetrical laminae, some can be divided again by a lateral (transverse) plane into two similar halves up

Fig. 22.

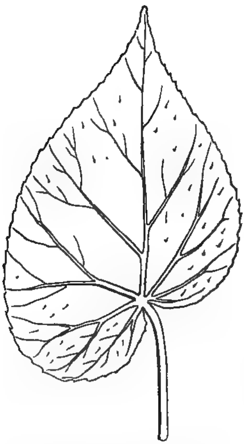

Fig. 22.—Unsymmetrical leaf of the Shūkaidō (*Begonia Evansiana*).

and down, as those of the Hasu (*Nelumbium speciosum*) (Fig. 23) and Inutsuge (*Ilex crenata*) (Fig. 24), while others, as those of the Natsume (*Zizyphus vulgaris*) (Fig. 27) and Satoimo, can not be divided into such similar halves; the former are said to be *Disymmetrical*, and the latter *Monosymmetrical.*

Symmetrical { Disymmetrical (Quadripartible). / Monosymmetrical (Bipartible).

The principal forms of disymmetrical laminae are *Orbicular* as in the Hasu (Fig. 13), *Elliptical* as in the Inutsuge

Fig. 23.

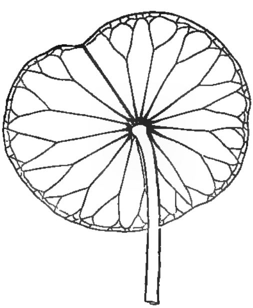

Fig. 23.—Orbicular leaf of the Hasu (*Nelumbium speciosum*).

Fig. 24.

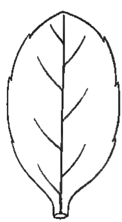

Fig. 24.—Elliptical leaf of the Inutsuge (*Ilex crenata*).

(Fig. 24), *Oblong* as in the Yudzuriha (Fig. 25), and *Linear* as in the Kōyamaki *(Sciadopitys verticillata)* (Fig. 26), etc.

Fig. 25.

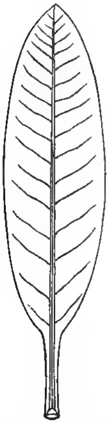

Fig. 25.—Coriaceous, biennial, entire, and oblong leaf of the Yudzuriha *(Daphniphyllum macropodum).*

Fig. 26.

Fig. 26.—Linear leaf of the Kōyamaki *(Sciadopitys verticillata).*

The principal forms of monosymmetrical laminae are *Ovate* as in the Mume and Natsume (Fig. 27), *Obovate* as in the Kobushi *(Magnolia Kobus)* (Fig. 28) and Mokuren *(M. obovata)*, *Lanceolate* as in the Momo *(Prunus persica)* and Shidareyanagi *(Salix babylonica)* (Fig. 31), *Oblanceolate* as in the Yayemugura *(Galium aparine)* (Fig. 29) and Numatorano-o *(Lysimachia Fortunei)*, *Acerose* as in the Sugi and Akamatsu (Fig. 32), *Spathulate* as in the Tabirako *(Eritrichium pedunculare)* (Fig. 30) and Darumagiku *(Aster spathulifolius)*, *Cordate* as in the Satoimo and Kōhone *(Nuphar japonicum)* (Fig. 33), *Reniform* as in the Agisumire *(Viola verecunda, var. semilunaris)* and Kakidōshi *(Nepeta Glechoma)* (Fig. 34), *Sagittate* as in the

Unagitsukami *(Polygonum strigosum)* (Fig. 35) and Nagahano-unagitsukami *(P. sagittatum)*, and *Hastate* as in the Mizosoba *(P. Thunbergii)* and Iwaomodaka *(Polypodium tricuspe)* (Fig. 36), etc.

FIG. 27.

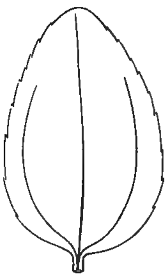

FIG. 27.—Ovate leaf of the Natsume *(Zizyphus vulgaris)*.

FIG. 28.

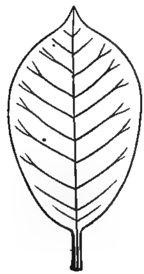

FIG. 28.—Obovate leaf of the Kobushi *(Magnolia Kobus)*.

FIG. 29.

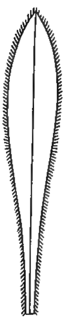

FIG. 29.—Oblanceolate leaf of the Yayemugura *(Galium aparine)*.

FIG. 30.

FIG. 30.—Spathulate leaf of the Tabirako *(Eritrichium pedunculare)*.

Fig. 31.

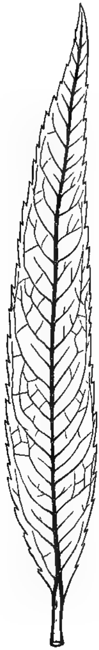

Fig. 32.

Fig. 33.

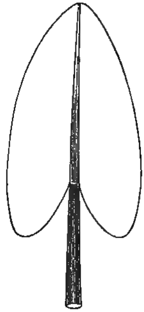

Fig. 33.—Cordate leaf of the Kōhone (*Nuphar japonicum*).

Fig. 34.

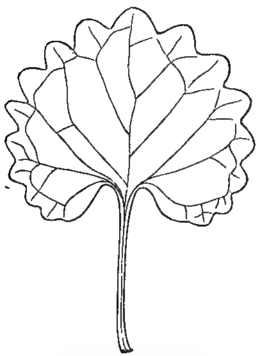

Fig. 34.—Reniform leaf of the Kakidōshi (*Nepeta Glechoma*).

Fig. 31.—Lanceolate leaf of the Shidareyanagi (*Salix babylonica*).

Fig. 32.—Acerose and fascicled leaves of the Akamatsu.

Fig. 35.

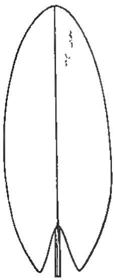

Fig. 35.—Sagittate leaf of the Unagitsukami (*Polygonum strigosum*).

Fig. 36.

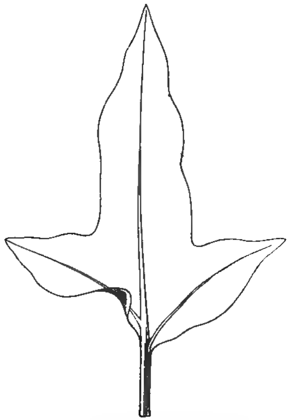

Fig. 36.—Hastate leaf of the Iwaomodaka (*Polypodium tricuspe*).

Unsymmetrical laminae have also several forms.

Different forms of laminae are represented in the following table.

Forms of laminae
- Symmetrical
  - Disymmetrical ...
    - Orbicular.
    - Elliptical.
    - Oblong.
    - Linear, etc.
  - Monosymmetrical
    - Ovate.
    - Obovate.
    - Lanceolate.
    - Oblanceolate.
    - Acerose.
    - Spathulate.
    - Cordate.
    - Reniform.
    - Sagittate.
    - Hastate, etc.
- Unsymmetrical.

4. *MARGINS OF THE LAMINA.*

In reference to the margin, the lamina may be either without notches of any kind as in the Yudzuriha (Fig. 25) and Kōhone (Fig. 33), or with notches of some kind as in the Sakura (Fig. 16) and Momiji (Fig. 18); when without notches the lamina is said to be *Entire* or *Even*, and when with notches *Uneven*.

MARGINS OF LAMINAE { Entire. / Uneven.

Among uneven laminae, some have their margins cut into numerous small indentations, as in the Mume and Sakura (Fig. 16); some have their margins deeply cut into divisions which extend not more than half way down, as in the Budō (Fig. 15) and Zeniaoi *(Malva sylvestris)*; some have deeper divisions which extend more than half way down, but do not reach to the midrib or the base, as in the Momiji (Fig. 18) and Yatsude; and others have still deeper divisions reaching to the midrib or the base, as in the Botan *(Pæonia Moutan)* and Karatachi *(Citrus trifoliata)* (Fig. 37). When its margins are cut into small indentations, the lamina is said to be *Dentate;* when cut into divisions extending not more than half way down, it is said to be *Lobed;* when the divisions are more than half way down, it is said to be *Parted;* and when the divisions reach to the midrib or the base, it is said to be *Divided.*

FIG. 37.

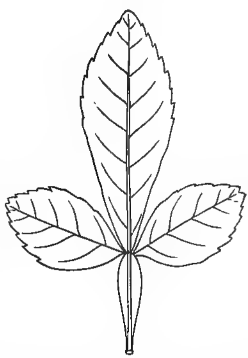

FIG. 37.—Palmately divided or compound leaf of the Karatachi *(Citrus trifoliata).*

MARGINS OF LAMINAE { Entire. / Uneven { Dentate. Lobed. Parted. Divided. }

The apex of the lamina varies much in different leaves: thus, it is either sharp as in the Shidareyanagi (Fig. 31); rounded as in the Kirishima *(Rhododendron indicum, var. obtusum)* and Tabirako (Fig. 30); abruptly pointed as in the Medohagi *(Lespedeza sericea)*; straight as if cut across as in the Tulip-tree; or notched as in the Katabami *(Oxalis corniculata)*. When sharp it is said to be *Acute;* when rounded, *Obtuse;* when abruptly pointed, *Mucronate;* when straight as if cut across, *Truncate;* and when more or less notched, *Emarginate.*

APEX OF THE LAMINA { Acute. Obtuse. Mucronate. Truncate. Emarginate. }

5. *INSERTION OF THE LAMINA.*

The lamina is inserted on the stem in different ways: in some leaves it arises immediately from the stem, as in the Doku-utsugi (Fig. 19) and Yayemugura (Fig. 29); while in others it is attached to the stem by means of the petiole or the sheath, as in the Momiji (Fig. 18) and Sakura (Fig. 16). The former kind of insertion is said to be *Direct*, and the latter *Indirect.*

INSERTION OF THE LAMINA { Direct. Indirect. }

Among the laminae whose insertions are direct, some have their margins near the base not at all united except at the point where they are attached to the stem, as in the

Doku-utsugi (Fig. 19) and Yayemugura (Fig. 29); while others have prolonged basilar lobes more or less united with the stem, as in the Kaizaiku *(Ammobium alatum)*. The direct insertion as in the former case is said to be *Free*, and that as in the latter *Adnate*.

FIG. 38.

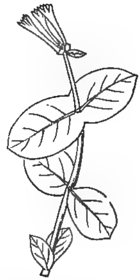

FIG. 38.—Tsuki-nukinindō *(Lonicera sempervirens, var. minor)*, with connate leaves.

DIRECT INSERTION { Free. / Adnate. }

Among adnate leaves, some have their basilar lobes united on the opposite side of the stem; some are opposite and have their bases cohering around the stem (Fig. 38); and others have their basilar lobes prolonged down the stem. In the first case, leaves are said to be Perfoliate; in the second, Connate; and in the last, Decurrent.

Among the laminae whose insertions are indirect, ordinary ones are attached to the petiole or the sheath by their bases, but others are fixed to the petiole by a point more or less within their margins, as in the Hasu (Fig. 23) and Junsai *(Brasenia peltata)*. The indirect insertion as in the former case is said to be *Basal*, and that as in the latter *Intramarginal*. When the lamina of a leaf is intramarginally attached to the petiole, the leaf is termed *Peltate*.

INDIRECT INSERTION { Basal. / Intramarginal. }

Different modes of insertion are represented in the following table.

INSERTION OF THE LAMINA {
- Direct { Free. / Adnate. }
- Indirect { Basal. / Intramarginal. }
}

b. The Petiole.

The Petiole is that portion of a leaf, which stands between the lamina and the sheath and is usually semicylindrical being branched or not. Not unfrequently the petiole presents foliaceous margins, as in the Yudzu *(Citrus aurantium)* (Fig. 47) and Nurude *(Rhus semi-alata)*, and is then said to be *Winged* or *Alate*.

DURATION OF THE PETIOLE.—The duration of the petiole is mostly similar with the lamina which it bears, but in a few cases it remains on the stem after its lamina falls off, as in the Aokatsura *(Sabia japonica)*.

c. The Leaf-sheath.

The Leaf-sheath is that portion of a leaf, which stands below the petiole and embraces the stem more or less assuming a tubular or sheath-like form. It is very much developed in Grasses, Sedges, and many Umbelliferae as the Nodake *(Angelica decursiva)*, Ashitaba *(A. kiusiana)*, etc.; in Grasses it is usually split in front, but in Sedges it is mostly closed.

It is often provided with two small leafy appendages which are situated one on each side of the leaf-sheath, as in the Sakura (Fig. 16) and Noibara *(Rosa multiflora)*. Those leafy appendages are called *Stipules*.

DURATION OF STIPULES.—The duration of stipules varies in different leaves: in some leaves, as those of the Mokuren and Sakura (Fig. 39), they fall off very soon; while in others, as those of the Noibara and Yendō *(Pisum sativum)*, they remain attached as long as the laminæ. The stipules of the former kind are said to be *Deciduous*, and those of the latter *Persistent*.

2. *ARRANGEMENT OF LEAVES ON THE STEM OR PHYLLOTAXIS.*

The various modes in which leaves are arranged on the stem are called *Phyllotaxis.*

Leaves are produced either singly at a node, as in the Mume and Sakura (Fig. 39), or two or more at the same node in the form of a whorl, as in the Aokiba *(Aucuba japonica)* (Fig. 41) and Yayemugura; the formre kind of phyllotaxis is said to be *Scattered* or *Unimerous,* and the latter *Polymerous.*

ARRANGEMENT OF LEAVES { Unimerous. / Polymerous.

The scattered leaves are ordinarily produced on the stem with elongated internodes, as in the Mume and Sakura (Fig. 39); but in some cases they are developed on a

FIG. 39.

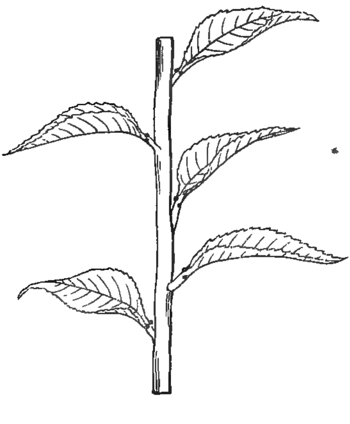

FIG. 39.—Shoot of the Sakura with alternate leaves.

FIG. 40.

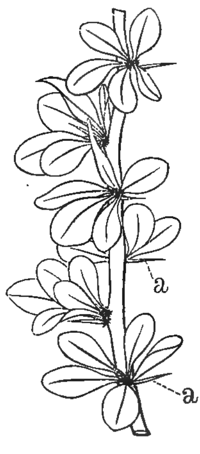

FIG. 40.—Shoot of the Megi *(Berberis Thunbergii),* with fascicled leaves. a Spine.

branch of which the internodes do not elongate, so that all the leaves of that branch are brought close together, as in the Akamatsu (Fig. 32) and Megi *(Berberis Thunbergii)* (Fig. 40). The leaves of the former arrangement are said to be *Alternate*, and those of the latter *Fascicled* or *Spuriously Verticillate.*

SCATTERED LEAVES { Alternate. Fascicled.

There are also two varieties among polymerous leaves: in one case, two leaves are produced at a node on opposite sides of the stem, as in the Nadeshiko *(Dianthus chinensis)* and Aokiba (Fig. 41); and in the other, three or more leaves are so produced at a node that the distance between any two adjacent leaves is equal, as in the Kyōchikutō *(Nerium odorum)* (Fig. 42) and Yayemugura.

FIG. 41.

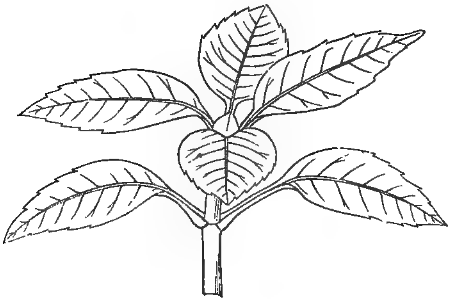

FIG. 41.—Shoot of the Aokiba *(Aucuba japonica)*, with opposite leaves.

The leaves of the former arrangement are said to be *Opposite*, and those of the latter *Verticillate.*

POLYMEROUS LEAVES { Opposite. Verticillate.

FIG 42.

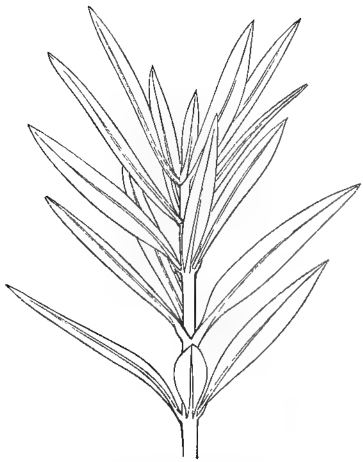

FIG. 42.—Shoot of the Kyōchikutō
(Nerium odorum),
with verticillate leaves.

Different kinds of the arrangement of leaves are represented in the following table.

ARRANGEMENT OF LEAVES	Scattered	Alternate.
		Fascicled.
	Polymerous	Opposite.
		Verticillate.

ANGULAR DIVERGENCE OF LEAVES.

The lateral distance between the bases of any two adjacent leaves is called the *Angular Divergence*, and it is expressed in fractions. In different individuals of the same species of plants the angular divergence is usually constant.

As the opposite leaves are exactly situated on opposite sides of the stem (Fig. 41), the angular divergence must be just one-half of the circumference.

In most cases the opposite leaves at any two adjacent nodes alternate (Fig. 41 and 43), so that the leaves at the first node lie opposite to or

below the leaves at the third node, and the leaves at the second node lie opposite to those at the fourth node, and so forth; hence, in this case there are found four longitudinal series of leaves placed up and down.

FIG. 43.

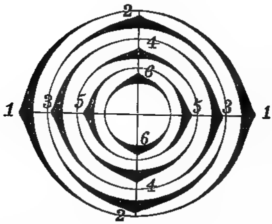

FIG. 43.—Diagram of a stem with opposite leaves; 1, 2, 3, 4, 5, 6, the successive whorls. (*Prantl.*)

These longitudinal series of leaves are called *Orthostichies* or *Vertical Ranks.*

In the whorl consisting of three leaves (Fig. 42), the anglar divergence must be one-third of the circumference, as the distance between any two adjacent leaves is equal. In this case also, the leaves at any two adjacent nodes alternate, so that the leaves at the first node lie opposite to the leaves at the third node, and so on; hence, there will be six longitudinal series of leaves placed up and down, or six vertical ranks of leaves.

If a whorl consists of four leaves, the angular divergence will be one-fourth of the circumference and there will be eight vertical ranks of leaves.

In the other kinds of verticillate leaves also, the angular divergence is usually found to be a fraction that has one for its numerator and the number of leaves at one node for its denominator, and the number of vertical ranks is just twice the number of leaves at one node.

FIG. 44.

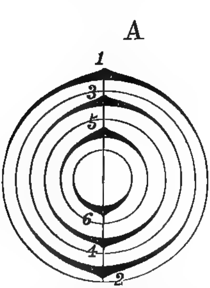

FIG. 44.—Diagram of a stem bearing alternate leaves with a divergence of $\frac{1}{2}$; 1, 2, 3, 4, 5, 6, the successive leaves. (*Prantl.*)

FIG. 45.

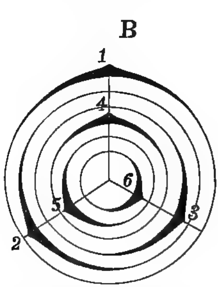

FIG. 45.—Diagram of a stem bearing alternate leaves with a divergence of $\frac{1}{3}$. (*Prantl.*)

In the simplest case of alternate leaves (Fig. 44), the leaf at the second node is above and exactly opposite to the leaf at the first node, and that at the third node is disposed vertically over the leaf at the first node. Hence, the angular divergence is here one-half of the circumference, and there are two vertical ranks of leaves. Now if we connect the bases of the leaves with a line from below upwards always in the same direction, a spiral will be drawn. As this spiral passes through the bases of leaves in the order of their development, it is called the *Genetic Spiral*. By the fraction $\frac{1}{2}$, not only the angular divergence is expressed, but also the numerator 1 denotes that there is one turn of the genetic spiral from one leaf to another which is disposed directly above, and the denominator 2 denotes that there are two vertical ranks.

In the next simpler case of alternate leaves, the fourth leaf that is one at the fourth node is placed vertically over the first leaf (Fig. 45); so that

FIG. 46.

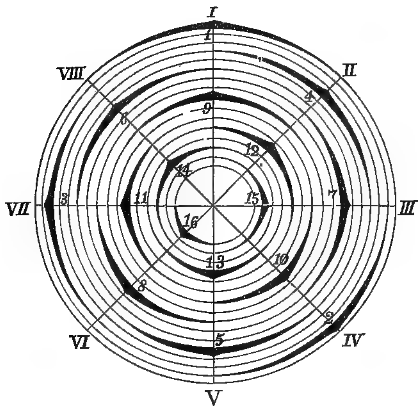

FIG. 46.—Diagram of a stem bearing alternate leaves with a divergence of $\frac{3}{8}$; I, II, III, etc., the vertical lines. *(Sachs.)*

the angular divergence is one-third of the circumference, vertical ranks are three, and the genetic spiral makes one turn round the stem from the first leaf to the fourth.

In the next case, the sixth leaf is placed directly above the first, so that the angular divergence is two-fifths, there being five vertical ranks and the genetic spiral making two turns.

In the next case, the ninth leaf is placed directly above the first, so that the angular divergence is three-eighths there being eight vertical ranks and three turns of the spiral.

In the next case, the angular divergence is five-thirteenths, the fourteenth leaf being placed vertically over the first; there are thirteen vertical ranks and five turns of the spiral.

Then follow such divergences as $\frac{8}{21}$, $\frac{13}{34}$, etc. If the preceeding fractions representing angular divergences are carefully observed, it will be seen that a certain relation exists between them; thus the sum of any two preceeding numerators is the numerator of the next succeeding fraction, and the same is true of the denominators. Therefore, the series of fractions representing the angular divergence may be expressed by the continued fraction,

$$\cfrac{1}{2+\cfrac{1}{1+\cfrac{1}{1+\cfrac{1}{1}}}}\text{, etc.}$$

$$\frac{1}{2}\text{(simplest angular divergence).}$$

$$\frac{1}{2+1}=\frac{1}{3}\text{(next angular divergence).}$$

$$\cfrac{1}{2+\cfrac{1}{1+1}}=\cfrac{1}{2+\cfrac{1}{2}}=\cfrac{1}{\cfrac{5}{2}}=\frac{2}{5}\text{(next angular divergence).}$$

There are still other divergences, but not common, as $\frac{1}{4}$, $\frac{2}{7}$, $\frac{2}{9}$, etc.

3. *KINDS OF FOLIAGE LEAVES IN REFERENCE TO THEIR COMPOSITION.*

Some foliage leaves have only one lamina and never more than one articulation at the base, as in the Mume and Sakura (Fig. 16); while others have two or more laminae, as in the Fuji *(Wistaria chinensis)* (Fig. 48) and Akebi *(Akebia quinata)* (Fig. 49), or one lamina and two articulations, as in the Yudzu (Fig. 47) and Megi. Those of the former kind are called *Simple Leaves* and those of the latter *Compound.*

KINDS OF FOLIAGE LEAVES IN REFERENCE TO THEIR COMPOSITION { Simple Leaves. / Compound Leaves.

Those compound leaves with one lamina, as in the Yudzu (Fig. 47) and Megi, are said to be *Unifoliolate*, and those with two or more laminae, as in the Fuji (Fig. 48) and Akebi (Fig. 49), are said to be *Multifoliolate*.

COMPOUND LEAVES { Unifoliolate. / Multifoliolate.

In compound leaves, their laminae are called *Leaflets*, the stalks of leaflets *Petiolules*, and the stipules of leaflets *Stipels*.

FIG. 47.

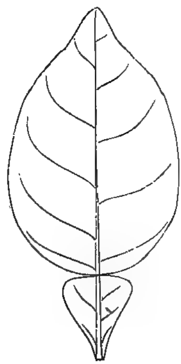

FIG. 47.—Unifoliolate compound leaf of the Yudzu *(Citrus aurantium)*.

FIG. 48.

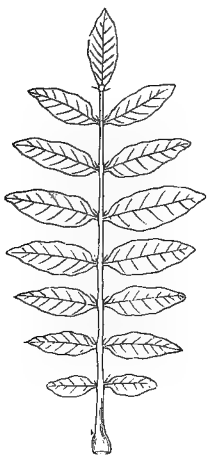

FIG. 48.—Pinnately compound leaf of the Fuji *(Wistaria chinensis)*.

FIG. 49.

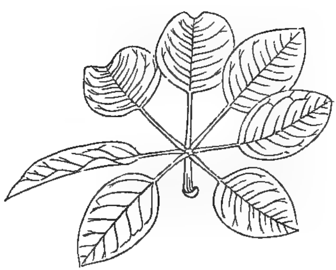

FIG. 49.—Palmately compound leaf of the Akebi *(Akebia quinata)*.

Some multifoliolate compound leaves have their leaflets arranged laterally on a common petiole, as in the Fuji (Fig. 48) and Yendō, while others have their leaflets arranged on the top of a common petiole, as in the Akebi (Fig. 49) and Tochinoki *(Aesculus turbinata)*.

Those of the former kind are called *Pinnately Compound Leaves* and those of the latter *Palmately Compound*.

MULTIFOLIOLATE COMPOUND LEAVES
- Pinnately Compound Leaves.
- Palmately Compound Leaves.

All the kinds of leaves in reference to their composition are represented in the following table.

KINDS OF LEAVES IN REFERENCE TO THEIR COMPOSITION
- Simple Leaves.
- Compound Leaves.........
  - Unifoliolate Compound Leaves.
  - Multifoliolate Compound Leaves......
    - Pinnately Compound Leaves.
    - Palmately Compound Leaves.

B. MODIFIED LEAVES.

Modified Leaves are those, which are either changed to perform some particular functions, or only retrograded from normal ones.

Some of the modified leaves are related either directly or indirectly to the nutrition of the plant to which they belong, as the insect-catching leaves of the Mōsengoke *(Drosera rotundifolia)* (Fig. 50) or the spines of the Megi (Fig. 40); while others are related either directly or indirectly to reproduction, as the fruit-bearing leaves of the Nokishinobu *(Polypodium lineare)* (Fig. 51) or the floral leaves of the Sakura (Fig. 55). Those of the former kind are said to be *Nutritive* or *Vegetative*, and those of the latter *Reproductive*.

MODIFIED LEAVES
- Nutritive.
- Reproductive.

Fig. 50.

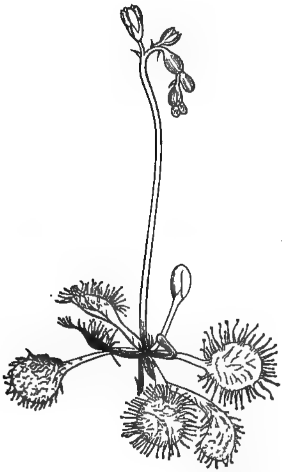

Fig. 50.—Mōsengoke (*Drosera rotundifolia*).

Fig. 51.

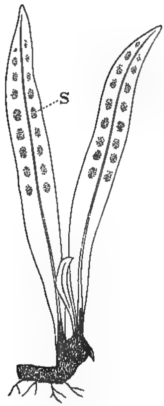

Fig. 51.—Nokishinobu (*Polypodium lineare*).
S. Clusters of spore-cases.

1. *NUTRITIVE MODIFIED LEAVES.*

There are many kinds of nutritive modified leaves: some are hard and needle-shaped, as the spines of the Megi (Fig. 40) and Hebinoboradzu *(Berberis vulgaris)*; some are thread-like and capable of coiling spirally, as the climbing organs of the Yendō and Shiode (Fig. 52); some are small and scaly, as the subterranean leaves of the Oniyuri (Fig. 12)

Fig. 52.

Fig. 52.—Shoot of the Shiode (*Smilax herbacea*) with tendrils.

and Jagataraimo (Fig. 14); and others are either flattened or bag-shaped, capable of catching insects, as the flattened leaves of the Mōsengoke (Fig. 50) or the bag-shaped leaflets of the Tanukimo *(Utricularia vulgaris).*

Those sharp-pointed leaves or parts of leaves are called *Spines;* those thread-like leaves or parts of leaves *Tendrils;* those scaly ones *Cataphyllary Leaves;* and those insect-catchers *Insectivorous Leaves.* (See Fig. 17.)

Not only leaves, but branches also are transformed into spines, as in the Saikachi *(Gleditschia japonica)* and Nashi *(Pyrus sinensis)*, and into tendrils, as in the Budō (Fig. 15) and Tsuta *(Vitis inconstans).* These modified branches may be readily distinguished from modified leaves by their point of origin (modified branches arise from axils of leaves or are direct continuations of stems).

NUTRITIVE MODIFIED LEAVES
- Spines.
- Tendrils.
- Cataphyllary Leaves.
- Insectivorous Leaves.

2. *REPRODUCTIVE MODIFIED LEAVES.*

There are also several kinds of reproductive modified leaves: in one case, numerous ones are clustered on a branch, of which the internodes are seldom developed, to subserve reproduction; some ones are situated below the above mentioned clusters to protect or help them, as the flower-covering-leaves of the Tennanshō *(Arisæma japonicum)* (Fig. 53) and Ayame; and others are scattered and bear minute fructifications, as in the Warabi *(Pteris aquilina)* and Nokishinobu (Fig. 51).

The group of numerous leaves modified to subserve reproduction is called a *Flower,* and its constituents are

FIG. 53.

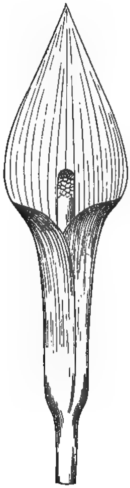

FIG. 53.—Inflorescence of the Tennanshō *(Arisaema japonicum)* enclosed in a scattered bract.

termed *Floral Leaves;* those situated below a flower or flowers *Hypsophyllary Leaves* or *Bracts;* and those bearing minute fructifications *Spore-bearing Leaves.* (See Fig. 17.)

REPRODUCTIVE MODIFIED LEAVES { Floral Leaves.
Hypsophyllary Leaves.
Spore-bearing Leaves.

FLORAL LEAVES.

The Floral Leaves are usually clustered into a group which is termed a *Flower.*

PARTS OF THE FLOWER.

A fully organized flower, as in the Kabura (Fig. 54) and Sakura (Fig. 55), consists of four different series of floral leaves: the outermost whorl called the *Calyx* is composed of flat-

FIG. 54.

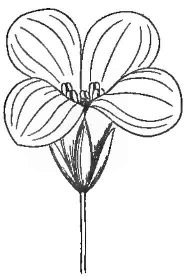

FIG. 54.—Flower of the Kabura *(Brassica campestris).*

FIG. 55.

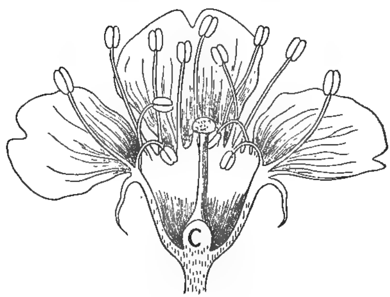

FIG. 55.—Flower of the Sakura cut open.

tened leafy organs ; the next whorl within the calyx called the *Corolla* is also composed of flattened leafy organs ; the third whorl within the corolla called the *Andrœcium* consists of more or less thread-like organs ; and the fourth series within the andrœcium called the *Gynœcium* occupies the centre of the flower and consists of more or less sac-like organs.

As the calyx and corolla are especially designed for the protection of the organs within, they are called *Protective Organs* or *Floral Envelopes ;* while the andrœcium and gynœcium are called *Essential Organs*, as they are indispensable for the main purpose of the flower.

PARTS OF THE FLOWER
- Protective Organs
  - Calyx.
  - Corolla.
- Essential Organs
  - Andrœcium.
  - Gynœcium.

THE CALYX.

The Calyx is the outermost envelope of the flower and it is composed of flattened usually green organs called *Sepals.*

DURATION OF THE CALYX.—The duration of the calyx varies in different plants: in some plants, as the Keshi *(Papaver somniferum)* and Kusanoō *(Chelidonium majus)*, it falls off when the flower expands ; in other plants, as the Kabura and Mume, it falls off with or after the corolla ; and in others, as the Kaki *(Diospyros Kaki)* and Hōdzuki *(Physalis Alkekengi)*, it remains after the flowering is over. The calyx of the first kind is said to be *Caducous* or *Fugacious ;* that of the second kind *Deciduous ;* and that of the third kind *Persistent.*

DURATION OF THE CALYX
- Caducous.
- Deciduous.
- Persistent.

KINDS OF THE CALYX.—The calyx is composed of either distinct sepals, as in the Kabura (Fig. 54) and Kimpōge *(Ranunculus acris)*; or more or less united sepals, as in the Mume and Sakura (Fig. 55). In the former case, it is said to be *Dialysepalous* or *Polysepalous*; and in the latter, *Gamosepalous* or *Monosepalous*.

KINDS OF THE CALYX { Dialysepalous Calyx.
Gamosepalous Calyx.

The dialysepalous calyx may be composed either of sepals of equal size and like form, as in the Kabura (Fig. 54) and Kimpōge; or of sepals of unequal size and unlike form, as in the Torikabuto *(Aconitum Fischeri)* and Sumire *(Viola Patrinii)* (Fig. 56). In the former case, it is said to be *Regular*, and in the latter *Irregular*.

FIG. 56.

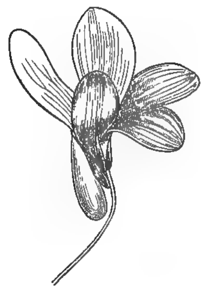

FIG. 56.—Flower of the Sumire *(Viola Patrinii)*.

DIALYSEPALOUS CALYX { Regular Dialysepalous Calyx.
Irregular Dialysepalous Calyx.

FIG. 57.

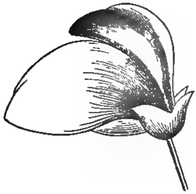

FIG. 57.—Flower of the Fuji.

The gamosepalous calyx may be also composed either of sepals of equal size and like form, as in the Mume and Sakura (Fig. 55); or of sepals of unequal size and unlike form, as in the Fuji (Fig. 57) and Odorikosō *(Lamium album)* (Fig. 59). In the former case, it is also called *Regular*, and in the latter *Irregular*.

GAMOSEPALOUS CALYX { Regular Gamosepalous Calyx.
Irregular Gamosepalous Calyx.

All the kinds of calyx are represented in the following table.

CALYX	Dialysepalous Calyx	Regular Dialysepalous Calyx.
		Irregular Dialysepalous Calyx.
	Gamosepalous Calyx	Regular Gamosepalous Calyx.
		Irregular Gamosepalous Calyx.

PARTS.—Although the sepals are modified leaves, yet commonly they are not provided with those portions corresponding to the petiole and sheath. In a gamosepalous calyx, the part where the sepals are united is called the *Tube*, the free border the *Limb*, and the opening of the tube the *Throat* (Fig. 59). Sometimes the limb of the calyx is developed in the form of scales or hairs called *Pappus*, as in the Tampopo *(Taraxacum officinale)* (Fig. 58) and Shion *(Aster tataricus)*.

FIG. 58.

FIG. 58.—Flower of the Tampopo *(Taraxacum officinale)*.

THE COROLLA.

The Corolla is the inner floral envelope situated within the calyx and it is composed of flattened usually colored organs called *Petals*.

DURATION OF THE COROLLA.—The duration of the corolla, like that of the calyx, varies in different plants. It is either *Caducous*, as in the Budō and Yabukarashi *(Vitis pentaphylla)*, *Deciduous*, as in the Mume and Keshi, or Persistent, as in the Doku-utsugi.

DURATION OF THE COROLLA	Caducous.
	Deciduous.
	Persistent.

Kinds of the Corolla.—The corolla is also composed either of separate petals, as in the Kimpōge and Sakura (Fig. 55); or of more or less united petals, as in the Asagao (Fig. 9) and Odorikosō (Fig. 59). In the former case, it is called *Dialypetalous* or *Polypetalous*, and in the latter *Gamopetalous* or *Monopetalous*.

Kinds of the corolla	Dialypetalous Corolla. Gamopetalous Corolla.

The dialypetalous corolla is again composed either of petals of equal size and like form, as in the Kimpōge and Sakura (Fig. 55); or of petals of unequal size and unlike form, as in the Sumire (Fig. 56) and Fuji (Fig. 57). In the former case, it is called *Regular* as in the calyx, and in the latter *Irregular*.

Dialypetalous corolla	Regular Dialypetalous Corolla. Irregular Dialypetalous Corolla.

The gamopetalous corolla is also either *Regular* as in the Asagao (Fig. 9) and Hōdzuki, or *Irregular*, as in the Odorikosō (Fig. 59) and Kiri *(Paulownia imperialis)*.

Gamopetalous corolla	Regular Gamopetalous Corolla. Irregular Gamopetalous Corolla.

All the kinds of corolla are represented in the following table.

Fig. 59.

Fig. 59.—Flower of the Odorikosō *(Lamium album)*.

COROLLA	Dialypetalous Corolla	Regular Dialypetalous Corolla.
		Irregular Dialypetalous Corolla.
	Gamopetalous Corolla	Regular Gamopetalous Corolla.
		Irregular Gamopetalous Corolla.

PARTS.—A fully developed petal consists of an expanded upper portion corresponding to the lamina of a leaf and a narrow stalk-like portion which is analogous to the petiole, as in the Nadeshiko and Gampi *(Lychnis grandiflora)* (Fig. 60). The expanded portion is called the *Limb*, and the petiolar portion the *Claw*. In a gamopetalous corolla, the part where the petals are united is also called the *Tube*, the free border the *Limb*, and the orifice of the tube the *Throat* (Fig. 59).

FIG. 60.

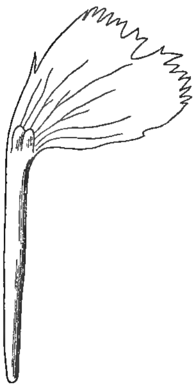

FIG. 60.—Petal of the Gampi *(Lychnis grandiflora)*.

THE ANDRŒCIUM.

The Andrœcium is the outer series of the essential organs situated within the corolla, and it is composed of one or more thread-like organs called *Stamens*.

PARTS OF THE STAMEN.—A fully organized stamen consists of a bag-like portion, which is analogous to the lamina, and a slender stalk, which is the representative of the petiole. The bag-like portion is called the *Anther* and the stalk the *Filament* (Fig. 65 and 67). The anther is usually divided into two equal halves which are separated perpendicularly by a central portion corresponding to the midrib. Each half is called an *Anther-lobe* and it has one or two cavities containing minute granules; and the central portion is

termed the *Connective.* The cavity of the anther is called the *Anther-cell*, and its granular contents are collectively termed the *Pollen.*

In a few cases, the anther is provided with only one lobe.

PARTS OF THE STAMEN $\begin{cases} \text{Anther} \begin{cases} \text{Anther-lobes—Pollen.} \\ \text{Connective.} \end{cases} \\ \text{Filament.} \end{cases}$

DURATION OF THE ANDRŒCIUM.—Most stamens fall off when their anthers discharge their contained pollen, as in the Keshi and Kabura, but in rare cases they remain after the flowering is over, as in the Hotarubukuro *(Campanula punctata)* and Fūrinsō *(C. Medium).* In the former case the andrœcium is said to be *deciduous*, and in the latter *Persistent.*

DURATION OF THE ANDRŒCIUM $\begin{cases} \text{Deciduous.} \\ \text{Persistent.} \end{cases}$

KINDS OF THE ANDRŒCIUM.—The andrœcium is composed either of separate stamens, as in the Kimpōge and

FIG. 61.

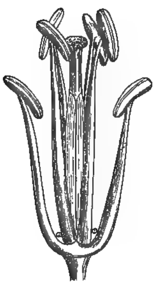

FIG. 61.—Tetradynamous andrœcium of the Kabura.

FIG. 62.

FIG. 62.—Diadelphous andrœcium of the Fuji.

Kabura (Fig. 61), or of more or less united stamens, as in the Fuji (Fig. 62) and Mukuge *(Hibiscus syriacus).* In

the former case, it is said to be *Apostemonous*, and in the latter, *Synstemonous.*

KINDS OF THE ANDRŒCIUM { Apostemonous Andrœcium. / Synstemonous Andrœcium.

FIG. 63.

FIG. 63.—Simple apostemonous andrœcium of the Myōga (*Zingiber Mioga*).

The apostemonous andrœcium may consist either of but one fertile stamen, as in the Myōga *(Zingiber Mioga)* (Fig. 63) and Dandoku *(Canna indica)*, or of two or more stamens, as in the Kitsunenomago *(Justicia procumbens)* and Kabura (Fig. 61). In the former case it is said to be *Simple*, and in the latter *Multiple.*

APOSTEMONOUS ANDRŒCIUM { Simple Apostemonous Andrœcium. / Multiple Apostemonous Andrœcium.

FIG. 64.

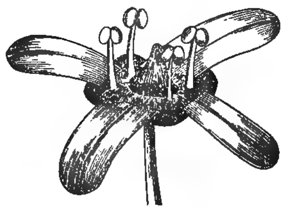

FIG. 64.—Flower of the Mayumi (*Euonymus europæus, var. Hamilitonianus*), showing the regular multiple apostemonous andrœcium.

The multiple apostemonous andrœcium may be composed either of those stamens which are all of the same length and like form, as in the Mayumi (*Euonymus europæus, var. Hamilitonianus)* (Fig. 64) and Ayame (see Fig. 69); or of those which are of different length or unlike form, as in the Kabura (Fig. 61) and Tsuyukusa *(Commelina communis)*. In the former case it is said to be *Regular*, and in the latter Irregular.

MULT. APOST. ANDR. { Reg. Mult. Apost. Andr. / Irreg. Mult. Apost. Andr.

The irregular multiple apostemonous andrœcium may be composed either of such unequal stamens as follow no definite rule, or of those arranged in a definite manner. In the latter case there are two important varieties: in one kind there are six stamens of which four are longer than the remaining two, as in the Kabura (Fig. 61) and Daikon; and in the other there are four stamens of which two are long and two short, as in the Odorikosō and Sagigoke *(Mazus rugosus, var. macranthus)* (Fig. 93). The andrœcium of the former sort is said to be *Tetradynamous*, and that of the latter *Didynamous*.

The synstemonous andrœcium may be composed either of those stamens which are united into one body by means of their anthers or their filaments, as in the Tampopo (Fig. 58) and Mukuge; or of those which are united into two or more bodies by their filaments, as in the Fuji (Fig. 62) and Otogirisō *(Hypericum erectum)*. The synstemonous andrœcium of the former kind is said to be *Complete*, and that of the latter *Incomplete*.

SYNSTEMONOUS ANDRŒCIUM	Complete Synstemonous Andrœcium. Incomplete Synstemonous Andrœcium.

A complete synstemonous andrœcium consisting of stamens which are united into one body by means of their anthers, as in the Tampopo (Fig. 58) and Shion, is said to be *Syngenesious;* and that composed of stamen which are united into one body by their filaments, as in the Mukuge and Zeniaoi, is said to be *Monadelphous.*

An incomplete synstemonous andrœcium consisting of stamens which are united into two separate bundles, as in the Fuji (Fig. 62) and Yendō, is said to be *Diadelphous;* that composed of stamens in three bundles, as in the Otogirisō and Midzuotogiri *(Hypericum virginicum)*, is said to be *Triadelphous;* and that consisting of stamens in four or more bundles, as in the Tomoyesō *(Hypericum Ascyron)* and Kinshibai *(H. patulum)*, is said to be *Polyadelphous.*

All the kinds of andrœcium are represented in the following table.

- ANDRŒCIUM
  - Apost. Andr.
    - Simp. Apost. Andr.
    - Mult. Apost. Andr.
      - Reg. Mult. Apost. Andr.
      - Irreg. Mult. Apost. Andr.
  - Synst. Andr.
    - Compl. Synst. Andr.
    - Incompl. Synst. Andr.

THE ANTHER.

ATTACHMENT OF THE ANTHER TO THE FILAMENT.—The attachment of the anther varies in different plants: in some plants, as the Magnolia (Fig. 65), the anther is attached on its back throughout its whole length to the filament; in some plants, as the Hebinoboradzu (Fig. 66) and all species of *Carex*, it is attached to the

FIG. 65.

FIG. 65.—Stamen of the Mokuren (*Magnolia obovata*), with adnate anther.

FIG. 66.

FIG. 66.—Stamen of the Hebinoboradzu (*Berberis vulgaris*), with innate anther.

FIG. 67.

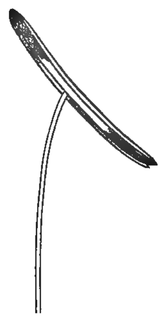

FIG. 67.—Stamen of the Oniyuri with versatile anther.

filament by its base, and its anther-lobes are mostly disposed oppositely; and in some plants, as the Oniyuri (Fig. 67) and Yamayuri (*Lilium auratum*), it is only attached by a point near its centre to the tip of the filament. When attached as in the first case, the anther is said to be *Adnate;* that attached as in the second case, *Innate;* and that as in the third case, *Versatile.*

ATTACHMENT OF THE ANTHER $\begin{cases} \text{Adnate.} \\ \text{Innate.} \\ \text{Versatile.} \end{cases}$

DIRECTION OF THE ANTHER.—The face of the anther is usually turned inwards towards the gynœcium, as in the

FIG. 68.

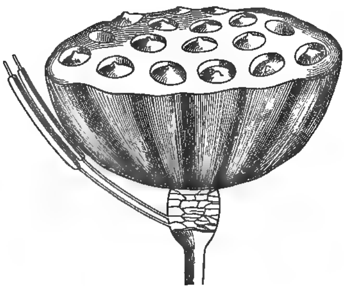

FIG. 68.—Introrse anthers of the Hasu.

FIG. 69.

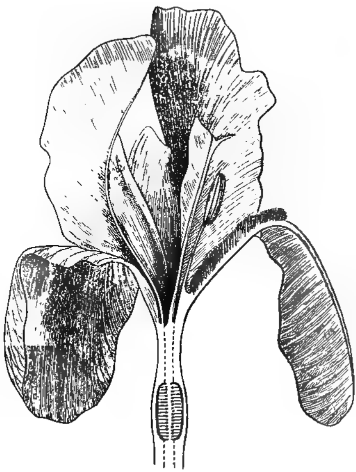

FIG. 69.—Flower of *Iris pumila*, with front portion and half of one petaloid style-lobe and stigma cut away, showing the ovary and a stamen with extrorse anther. *(Gray.)*

Hasu (Fig. 68), but sometimes the face is turned outwards towards the floral envelopes, as in the Ayame (see Fig. 69). When turned inwards the anther is said to be *Introrse;* and when turned outwards it is said to be *Extrorse.*

DIRECTION OF THE ANTHER { Introrse. / Extrorse.

DEHISCENCE OF THE ANTHER.—The act of discharging its contained pollen is called the *Dehiscence of the Anther.* This dehiscence takes place in different ways: in the commonest case each anther-lobe opens longitudinally, as in the Mokuren (Fig. 65) and Hasu (Fig. 68); in some cases it splits transversely, as in the Hinjimo *(Lemna trisulca)*

FIG. 70.

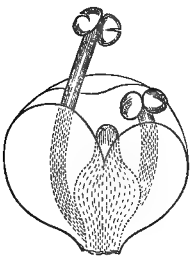

FIG. 70.—Flower of the Hinjimo *(Lemna trisulca)* with anthers opening transversely.

FIG. 71.

FIG. 71.—Stamen of the Nasubi *(Solanum Melongena)* with the anther opening by pores.

(Fig. 70); in some it opens by a hole or holes, as in the Nasubi *(Solanum Melongena)* (Fig. 71) and Tsutsuji *(Rhododendron indicum)*; and in others the whole or portions of its face open like trap-doors, as in the Hebinoboradzu (Fig. 66) and all species of *Lindera.* The first kind of dehiscence is said to be *Longitudinal,* the second kind *Transverse,* the third kind *Porous,* and the last *Valvular.*

DEHISCENCE OF THE ANTHER	Longitudinal. Transverse. Porous. Valvular.

THE GYNŒCIUM.

The Gynœcium is the inner series of the essential organs occupying the centre of the flower, and it is composed of one or more usually sac-like organs called *Carpels*. Although the carpels are mostly sac-like as in the Mume and Sakura, yet in a few cases they are open and scale-like as in the species of *Pinus* and they are consequently called *Open* or *Gymnospermous Carpels*. (See Fig. 127.)

PARTS OF THE CARPEL.—The ordinary uncombined carpel is made up of the lamina of a leaf, both halves of which are incurved lengthwise and united by their margins. Thus a flask-shaped organ is formed: its inflated lower portion is called the *Ovary ;* its prolonged neck-like portion, the *Style ;* and its usually dilated rough apex, the *Stigma* (Fig. 55). The cavity of the ovary is termed its *Cell*, the line formed by the union of the leaf-margins the *Inner* or *Ventral Suture*, and the line corresponding to the midrib of the leaf the *Outer* or *Dorsal Suture*.

Usually the interior surface of the inner suture projects more or less and bears one or more minute bodies ; the projecting portion is called the *Placenta*, and the minute bodies, which become *Seeds* when fully ripe, are called *Ovules*.

As the ovary and stigma are the essential parts of the carpel they are always present, but sometimes the style is wanting.

PARTS OF THE CARPEL	Ovary—Ovule. Style. Stigma.

DURATION OF THE GYNŒCIUM.—The gynœcium does not fall off as the other parts of the flower commonly do, but it becomes the *Fruit* when fully ripened.

KINDS OF THE GYNŒCIUM.—The gynœcium is composed either of separate carpels, as in the Fukujusō *(Adonis amurensis)* and Kimpōge (Fig. 72), or of more or less united ones, as in the Oniyuri (Fig. 73) and Sumire (Fig. 74). In the former case it is said to be *Apocarpous*, and in the latter *Syncarpous*.

KINDS OF THE GYNŒCIUM { Apocarpous Gynœcium.
Syncarpous Gynœcium.

FIG. 72.

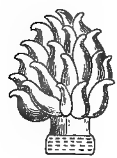

FIG. 72.—Multiple apocarpous gynœcium of the Kimpōge *(Ranunculus acris)*.

The apocarpous gynœcium may consist of either but one carpel, as in the Sakura (Fig. 55) and Yendō, or two or more, as in the Kimpōge (Fig. 72) and Fukujusō. In the former case it is said to be *Simple*, and in the latter *Multiple*.

In the multiple apocarpous gynœcium the ventral suture of each carpel is turned inwards.

APOCARPOUS GYNŒCIUM { Simple Apocarpous Gynœcium.
Multiple Apocarpous Gynœcium.

The syncarpous gynœcium may be two- or more-celled being composed of two or more completely closed carpels, as in the Oniyuri (Fig. 73) and Nashi, or one-celled being composed of those more or less open carpels which are united together by their contiguous margins, as in the Keshi and Sumire (Fig. 74), or one-celled from the rupture of dissepiments, as in the Hakobe *(Stellaria media)* and Gampi.

The syncarpous gynœcium of the first kind is said to be *Multilocular*, and that of the second and the third *Unilocular*.

FIG. 73.

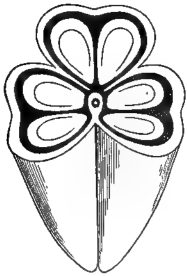

FIG. 73.—Cross section of the multilocular syncarpous gynœcium of the Oniyuri, showing axile placentation.

FIG. 74.

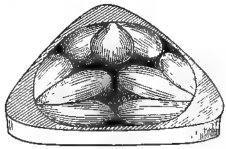

FIG. 74.—Cross section of the unilocular syncarpous gynœcium of the Sumire, showing parietal placentation.

SYNCARPOUS GYNŒCIUM { Unilocular Syncarpous Gynœcium.
Multilocular Syncarpous Gynœcium.

In the apocarpous gynœcium, as the placenta is always situated on the interior surface of the ovary, the placentation (the manner in which the placentas are distributed) is said to be *Parietal* (Fig. 55). In the multilocular syncarpous gynœcium, as the placentas are arranged in the centre, the placentation is said to be *Axile* (Fig. 73). In the unilocular syncarpous gynœcium composed of those open carpels which are united together by their contiguous margins, the placentation is mostly *Parietal* (Fig. 74). But, in the unilocular syncarpous gynœcium composed of those carpels which have lost their dissepiments, as the placentas are situated in the centre of the cavity and perfectly unconnected with the wall, the placentation is said to be *Free Central;* and in the ordinary unilocular syncarpous one, the free central placentation is sometimes formed by the growth of a placental column from the base of the ovary-cavity. (See Fig. 78.)

All the kinds of gynœcium are represented in the following table.

GYNŒCIUM {
Apocarpous Gynœcium { Simple Apocarpous Gynœcium.
Multiple Apocarpous Gynœcium.
Syncarpous Gynœcium { Unilocular Syncarpous Gynœcium.
Multilocular Syncarpous Gynœcium.

THE FRUIT.

The Fruit is the ripened gynœcium, and it contains one or more seeds which are the ripened ovules.

PARTS OF THE FRUIT.—The ordinary fruit consists of two parts: namely, of the fruit-coat called the *Pericarp*, which is either thin, as in the Kabura and Daidzu, or thick, as in the Mume and Momo (Fig. 84); and of one or more seeds. Although the pericarp consists normally of the mature ovary-coat or ovary-coats, as in the Mume and Kaki, sometimes the calyx and receptacle (page 75) also enter into its composition, as in the Nashi, (Fig. 86) and Ringo *(Pyrus Malus, var. tomentosa)*.

When very thick, the pericarp is divisible into three layers, an external called the *Exocarp;* a middle, the *Mesocarp;* and an inner, the *Endocarp*. The exocarp is mostly tough and thin; the mesocarp often very thick and fleshy; and the endocarp is sometimes thick and very hard.

When thick and very hard the endocarp is termed the *Stone* or *Putamen;* such endocarp is seen in the fruits of the Mume and Momo (Fig. 84).

$$\text{PARTS OF THE FRUIT}\begin{cases}\text{Pericarp}\begin{cases}\text{Exocarp.}\\\text{Mesocarp.}\\\text{Endocarp.}\end{cases}\\\text{Seeds.}\end{cases}$$

DURATION OF THE FRUIT.—Some fruits fall off when fully ripe, as those of the Mume and Momo, but others remain permanently on the stem even after the plant dies, as those of the Daidzu and Tōgarashi *(Capsicum longum)*. Those of the former kind are said to be *Deciduous*, and those of the latter *Persistent*.

$$\text{DURATION OF THE FRUIT}\begin{cases}\text{Deciduous.}\\\text{Persistent.}\end{cases}$$

KINDS OF THE FRUIT.—Some fruits are formed from single flowers, as those of the Sakura (see Fig. 55) and Momo (Fig. 84), while others are formed by the combination of several flowers, as those of the Kuwa *(Morus alba)* (Fig. 88) and Ichijiku *(Ficus carica)*. Those of the former kind are said to be *Monothalamic*, and those of the latter *Polythalamic*.

KINDS OF THE FRUIT { Monothalamic Fruit.
Polythalamic Fruit.

Monothalamic fruits may be composed either of one or more separate mature carpels, as in the Momo (Fig. 84) and Kimpōge (Fig. 72), or of more or less united mature carpels, as in the Kabura and Nashi (Fig. 86). In the former case, they are said to be *Apocarpous*, and in the latter *Syncarpous*.

MONOTHALAMIC FRUIT { Apocarpous Fruit
Syncarpous Fruit.

Apocarpous fruits may be also Simple or Multiple.

APOCARPOUS FRUIT { Simple Apocarpous Fruit.
Multiple Apocarpous Fruit.

Monothalamic fruits whether apocarpous or syncarpous are either dry, as in the Kimpōge and Kabura, or fleshy, as in the Momo (Fig. 84) and Nashi (Fig. 86).

MONOTHALAMIC FRUIT { Dry Monothalamic Fruit.
Fleshy Monothalamic Fruit.

Some of the dry monothalamic fruits burst open or separate into pieces when mature, as those of the Ingen (Phaseolus vulgaris) (Fig. 76) and Nagashirami (Osmorhiza japonica) (Fig. 79); while others remain closed, as those of the Kimpōge (Fig. 72) and Tōgarashi (Fig. 81). Those of the former kind are said to be *Dehiscent*, and those of the latter *Indehiscent*.

DRY MONOTHALAMIC FRUIT { Dehiscent Dry Monothalamic Fruit.
Indehiscent Dry Monothalamic Fruit.

Among dehiscent dry monothalamic fruits, some are apocarpous and each one opens by one suture only, as in the Yamaodamaki *(Aquilegia Buergeriana)* (Fig. 75) and Torikabuto; some are also apocarpous and each one opens by two sutures, as in the Daidzu and Ingen (Fig. 76); some

FIG. 75.

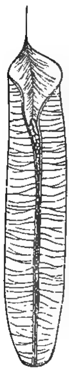

FIG. 75.—Follicle of the Yamaodamaki *(Aquilegia Buergeriana)*.

FIG. 76.

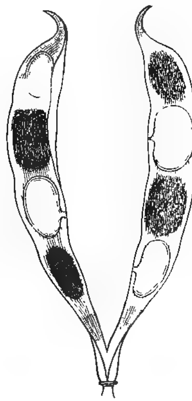

FIG. 76.—Legume of the Ingen *(Phaseolus vulgaris)*.

FIG. 77.

FIG. 77.—Capsule of *Cardamine*.

FIG. 78.

FIG. 78.—Capsule of the Matsubabotan *(Portulaca grandiflora)*.

FIG. 79.

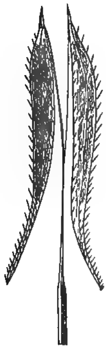

FIG. 79.—Schizocarp of the Nagashirami (*Osmorhiza japonica*).

are syncarpous and burst open, as in the Kabura (see Fig. 77), Matsubabotan (*Portulaca grandiflora*) (Fig. 78), and Tsubaki; and others are also syncarpous and separate into their constituent carpels without opening, as in the Ninjin and Nagashirami (Fig. 79). In the first case the fruit is called the *Follicle;* in the second, the *Legume;* in the third, the *Capsule;* and in the last, the *Schizocarp.*

DEHISCENT DRY MONOTHALAMIC FRUIT { Follicle. Legume. Capsule. Schizocarp.

Among indehiscent dry monothalamic fruits, some have hard pericarps and are usually one-seeded, as in the Shira-

FIG. 80.

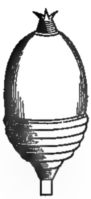

FIG. 80.—Nut of the Shirakashi (*Quercus glauca*).

FIG. 81.

FIG. 81.—Indehiscent capsule of the Tōgarashi (*Capsicum longum*).

FIG. 82.

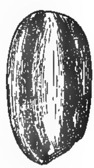

FIG. 82.—Grain of the Ine.

FIG. 83.

FIG. 83.—Grain of the Ōmugi (*Hordeum vulgare*).

kashi *(Quercus glauca)* (Fig. 80) and Kuri *(Castanea vulgaris*, var. *japonica)* ; some have not hard pericarps and are usually many-seeded, as in the Daikon and Tōgarashi (Fig. 81); some are small and somewhat seed-like, each fruit being provided with a pericarp separable from the seed or seeds, as in the Kimpōge (Fig. 72) and Fukujusō; and others are also small, each one being provided with such a pericarp as is inseparably united with the seed, as in the Ine (Fig. 82) and Ōmugi *(Hordeum vulgare)* (Fig. 83). In the first case the fruit is called the *Nut ;* in the second, the *Indehiscent Capsule ;* in the third, the *Achene ;* and in the last, the *Grain or Caryopsis.*

INDEHISCENT DRY MONOTHALAMIC FRUIT { Nut. / Indehiscent Capsule. / Achene. / Grain. }

FIG. 84.

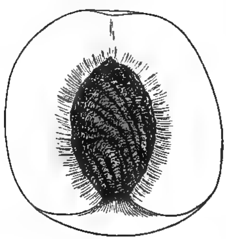

FIG. 84.—Drupe of the Momo *(Prunus persica)*.

In some of the fleshy monothalamic fruits, as those of the Mume and Momo (Fig. 84), the endocarp is very hard and called the stone; while in others as those of the Budō (Fig. 15) and Kaki, the endocarp is not so hard. Those fruits, in which the endocarp is very hard, are called *Drupes.*

FLESHY MONOTH. FR. { Fleshy Monoth. Fr. with a stone-Drupe. / Fleshy Monoth. Fr. without a stone. }

In some of the fleshy monothalamic fruits in which the endocarp is not so hard, the pericarp is soft throughout, as in the Kaki and Budō (Fig. 15); in some, the pericarp is soft internally and hard externally, as in the Tōnasu

(Cucurbita Pepo) and Hyōtan *(Lagenaria vulgaris)* (Fig. 85); and in others, the endocarp is papery, cartilaginous, or bony, and surrounded by a thick flesh which belongs chiefly to the adnate calyx, as in the Nashi (Fig. 86) and Ringo.

FIG. 85.

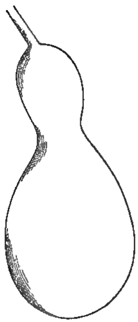

FIG. 85.—Pepo of the Hyōtan *(Lagenaria vulgaris)*.

FIG. 86.

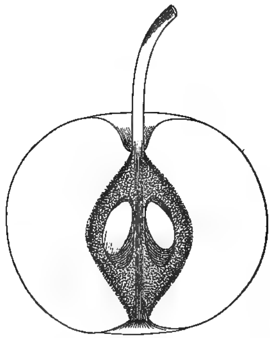

FIG. 86.—Pome of the Nashi *(Pyrus sinensis)*.

In the first case the fruit is called the *Berry;* in the second, the *Pepo;* and in the last, the *Pome.*

FLESHY MONOTH. FR. WITHOUT A STONE $\begin{cases} \text{Berry.} \\ \text{Pepo.} \\ \text{Pome.} \end{cases}$

FIG. 87.

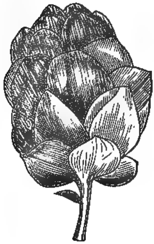

FIG. 87.—Dry polythalamic fruit of the Karahanasō *(Humulus Lupulus)*.

FIG. 88.

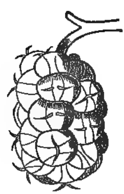

FIG. 88.—Fleshy polythalamic fruit of *Morus.*

Among polythalamic fruits also, some are dry as in the Akamatsu and Karahanasō *(Humulus Lupulus, var. cordifolius)* (Fig. 87), while others are fleshy as in the Kuwa (Fig. 88) and Ichijiku.

POLYTHALAMIC FRUIT
- Dry Polythalamic Fruit.
- Fleshy Polythalamic Fruit.

All the kinds of fruits are represented in the following table.

FRUIT
- Monoth. Fr.
  - Dry Monoth. Fr. ...
    - Dehis. Monoth. Fr.
      - Follicle.
      - Legume.
      - Capsule.
      - Schizocarp.
    - Indehis. Monoth. Fr.
      - Nut.
      - Indehiscent Capsule.
      - Achene.
      - Grain.
  - Fleshy Monoth. Fr.
    - Fleshy Monoth. Fr. with a stone—Drupe.
    - Fleshy Monoth. Fr. without a stone....
      - Berry.
      - Pepo.
      - Pome.
- Polyth. Fr.
  - Dry Polyth. Fr.
  - Fleshy Polyth. Fr.

THE SEED.

The Seed is the ripened ovule and it always contains a rudimentary plant called the *Embryo.*

PARTS OF THE SEED.—The seed consists of the inner substance called the *Kernel* and its integuments termed the *Seed-coats.*

The kernel consists of the embryo alone as in the seeds of the Daidzu and Kabura, or of the embryo and its nutritive matter called the *Albumen* as in those of the Asagao and Ine.

The embryo being the rudimentary plant consists of an axis and one or more leaves. The apex of the axis is called the *Plumule*, its lower end the *Radicle*, its portion between the plumule and the radicle the *Caulicle*, and the leaves bear the name of *Cotyledons*.

The seed-coats usually consist of two layers; namely, of the exterior integument called the *Testa* which is thick and often very hard, and of the interior one called the *Tegmen* which is commonly thin and delicate.

PARTS OF THE SEED
- Seed-coats
  - Testa.
  - Tegmen.
- Kernel
  - Embryo
    - Radicle.
    - Caúlicle.
    - Plumule.
    - Cotyledons.
  - Albumen.

KINDS OF THE SEED.—In some seeds, as those of the Ayame and Ōmugi (Fig. 89), the embryo has only one cotyledon; in some, as those of the Asagao (Fig. 90) and

FIG. 89.

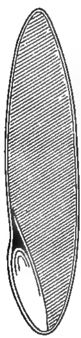

FIG. 89.—Monocotyledonous seed of the Ōmugi.

FIG. 90.

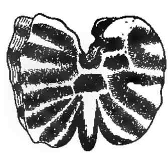

FIG. 90.—Dicotyledonous seed of the Asagao.

FIG. 91.

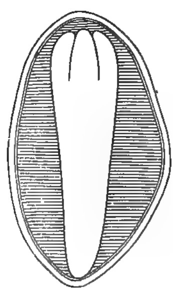

FIG. 91.—Polycotyledonous seed of the Akamatsu.

Daidzu, it has two cotyledons; and in others, as those of the species of *Pinus* (Fig. 91), it has three or more cotyledons.

In the first case the seed is said to be *Monocotyledonous;* in the second, *Dicotyledonous;* and in the last, *Polycotyledonous.*

KINDS OF THE SEED { Monocotyledonous Seed.
Dicotyledonous Seed.
Polycotyledonous Seed.

KINDS OF THE FLOWER.

Flowers vary according to either their floral envelopes, or their essential organs, so that they may be classified in two ways.

KINDS OF FLOWERS ACCORDING TO THEIR FLORAL ENVELOPES.

In some plants as the Mume and Sakura (Fig. 55) the flower possesses the corolla, while in others as the Jinchōge *(Daphne odora)* and Nawashirogumi *(Elæagnus pungens)* (Fig. 94) it does not possess the corolla. In the former case the flower is said to be *Petalous* or *Dichlamydeous*, and in the latter *Apetalous.*

FLOWER { Petalous Flower.
Apetalous Flower.

In some of the petalous flowers, the corolla is dialypetalous as in the Kabura (Fig. 54) and Sakura (Fig 55); while in others it is Gamopetalous as in the Asagao (Fig. 9) and Odorikosō (Fig. 59). In the former case the flower is said to be *Dialypetalous*, and in the latter *Gamopetalous.*

PETALOUS FLOWER { Dialypetalous Flower.
Gamopetalous Flower.

In some of the dialypetalous flowers, the corolla is quite separated from the calyx, as in the Kabura (Fig. 54) and

Kimpōge ; while in others, the corolla arises from the calyx, as in the Mume and Sakura (Fig. 55). The flowers of the former kind are said to be *Free Dialypetalous*, and those of the latter *Adherent Dialypetalous*.

DIALYPETALOUS FLOWER	Free Dialypetalous Flower. Adherent Dialypetalous Flower.

Free dialypetalous flowers may be either *Regular* as in the Kabura (Fig. 54) and Kimpōge, or *Irregular* as in the Sumire (Fig 56) and Murasakikeman *(Corydalis incisa)*.

FREE DIALYPETALOUS FLOWER	Regular Free Dialypetalous Flower. Irregular Free Dialypetalous Flower.

Adherent dialypetalous flowers also may be sometimes *Regular* as in the Mume and Sakura (Fig. 55) or at other times *Irregular* as in the Fuji (Fig. 57) and Ingen.

ADHERENT DIALYPETALOUS FLOWER	Regular Adherent Dialypetalous Flower. Irregular Adherent Dialypetalous Flower.

In some of the irregular adherent dialypetalous flowers, the andrœcium is united with the style, and such flowers are said to be *Orchidaceous;* and in some again, the corolla consists of five petals, of which the outermost one is usually the largest, the innermost two are often coherent in front inclosing the essential organs, and the lateral two are somewhat wing-like, and such flowers are said to be *Papilionaceous* (Fig. 57).

In some gamopetalous flowers, the ovary or ovaries are united with the calyx tube, as in the Tampopo (Fig. 58) and Hakone-utsugi *(Diervilla grandiflora)* (Fig. 92) ; while in others, the ovary or ovaries are quite separated from the calyx, as in the Tsutsuji and Sagigoke (Fig. 93). In the former case, the flower is said to be *Epigynous*, and in the latter *Hypogynous.*

FIG. 92.

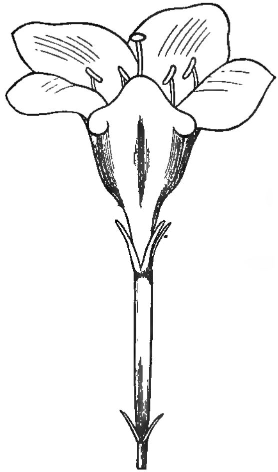

FIG. 92.—Flower of the Hakone-utsugi *(Diervilla grandiflora)*.

FIG. 93.

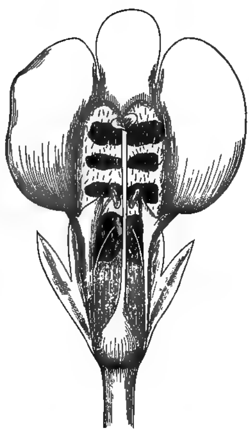

FIG. 93.—Flower of the Sagigoke *(Mazus rugosus)* cut open.

GAMOPETALOUS FLOWER { Epigynous Gamopetalous Flower.
Hypogynous Gamopetalous Flower.

Epigynous gamopetalous flowers may be either *Regular* as in the Hakone-utsugi (Fig. 92) and Kikyō *(Platycodon grandiflorum)*, or *Irregular* as in the Tampopo (Fig. 58) and Nindō *(Lonicera japonica)*.

EPIGYNOUS GAMOPETALOUS FLOWER { Regular Epig. Gamop. Fl.
Irregular Epig. Gamop. Fl.

Hypogynous gamopetalous flowers also may be either *Regular* as in the Asagao (Fig. 9) and Sakurasō *(Primula cortusoides)*, or *Irregular* as in the Kiri and Sagigoke (Fig. 93).

HYPOGYNOUS GAMOPETALOUS FLOWER { Reg. Hypog. Gamop. Fl.
Irreg. Hypog. Gamop. Fl.

In some of the irregular hypogynous gamopetalous flowers, the corolla is five-lobed and the limb is divided into two portions, which are placed superiorly and inferiorly, somewhat resembling the lips and open mouth of an animal, and such flowers are said to be *Labiate* (Fig. 59); and in others, petals are united on one side to form a flattened strap, and such flowers are said to be *Ligulate* (Fig. 58).

FIG. 94.

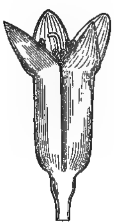

FIG. 94.—Flower of the Nawashirogumi (*Elæagnus pungens*).

FIG. 95.

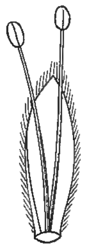

FIG. 95.—Male flower of the Shidareyanagi.

FIG. 96.

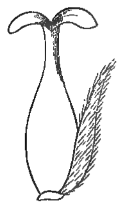

FIG. 96.—Female flower of the Shidareyanagi.

In some of the apetalous flowers, the calyx is present as in the Jinchōge and Nawashirogumi (Fig. 94); while in others, it is absent as in the Akamatsu and Shidareyanagi (Fig. 95 and 96). In the former case, the flower is said to be *Monochlamydeous*, and in the latter *Achlamydeous*.

APETALOUS FLOWER $\left\{ \begin{array}{l} \text{Monochlamydeous Flower.} \\ \text{Achlamydeous Flower.} \end{array} \right.$

2. *KINDS OF FLOWERS ACCORDING TO THEIR ESSENTIAL ORGANS.*

In some cases, the androecium and the gynoecium may be both present, as in the Mume and Sakura (Fig. 55); in some cases, either the androecium or the gynoecium may be absent, that is, only one of the essential organs may be present, as in the Shidareyanagi (Fig. 95 and 96) and Akamatsu; and in other cases, the essential organs may be altogether

wanting, as the outermost flowers of the Yagurumagiku *(Centaurea Cyanus)* and Ajisai *(Hydrangea hortensis, var. Azisai)* (Fig. 97). Those flowers which possess both essential organs are said to be *Bisexual* or *Hermaphrodite;* those in which only one is present are *Unisexual* or *Diclinous;* and those which possess neither andrœcium nor gynœcium are *Neutral.*

FIG. 97.

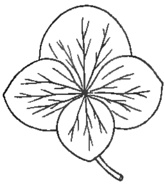

FIG. 97.—Neutral flower of the Ajisai *(Hydrangea hortensis, var. Azisai).*

KINDS OF FLOWERS ACCORDING TO THEIR ESSENTIAL ORGANS
- Bisexual Flower.
- Unisexual Flower.
- Neutral Flower.

When a flower consists of four parts, namely, calyx, corolla, andrœcium, and gynœcium, as in the Kabura and Sakura, it is said to be *Complete.*

When a flower wants one or more parts, as in the Jinchōge and Shidare-yanagi, it is said to be *Incomplete.*

When each part of a flower consists of an equal number of constituents or the constituents of one part are multiples of those of another, as in the Ama *(Linum usitatissimum)* and Kirinsō *(Sedum kamtschaticum),* the flower is said to be *Symmetrical.*

When each part of a flower consists of an unequal number of constituents or the constituents of one part are not multiples of those of another, as in the Keshi and Mume, the flower is said to be *Unsymmetrical.*

HYPSOPHYLLARY LEAVES OR BRACTS.

The Hypsophyllary Leaves or Bracts are modified leaves situated below the flower or flowers. They are developed either singly as in the Tennanshō (Fig. 53) and Ayame, or in whorls as in the Ichirinsō *(Anemone nikoensis)* (Fig. 98) and Riunōgiku *(Chrysanthemum sinense, var. japonicum)* (Fig. 99). In the former case, they are said to be *Scattered,* and in the latter, *Verticillate.*

FIG. 98.

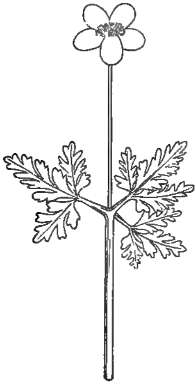

FIG. 98.—Ichirinsō (*Anemone nikoensis*).

FIG. 99.

FIG. 99.—Flower-clusters of the Riunōgiku (*Chrysanthemum sinense, var. japonicum*).

BRACTS { Scattered.
Verticillate.

THE INFLORESCENCE.

The arrangement of the flowers on the axis is termed the *Inflorescence.*

PARTS OF THE INFLORESCENCE.—In a well developed inflorescence, there is a common axis, branched or not branched, on which stalked or sessile flowers and usually bracts are developed. The axis is called the *Peduncle;* the stalk of the flower, the *Pedicel;* and the apex of the pedicel or peduncle, upon which the parts of a flower are arranged, the *Receptacle.* Sometimes the peduncle is more or less dilated and bears numerous flowers; it is then called the *Common Receptacle.* (See Fig. 17.)

PARTS OF THE INFLORESCENCE { Peduncle.
Flowers with or without Pedicels.
Bracts.

KINDS OF THE INFLORESCENCE.—In some plants, the main axis or common peduncle of the inflorescence is not terminated by a flower, as in the Kabura and Fuji (see Fig. 100); while in others, the common peduncle is terminated by a flower, as in the Nadeshiko and Kinshibai (see Fig. 104). The former kind is called the *Indefinite,* and the latter the *Definite Inflorescence.* In the indefinite inflorescence with an elongated common peduncle, as the flowers open in succession from below upwards, it is also called the *Ascending* (Fig 100 and 101). When the common peduncle is shortened, the flowers open from the circumference towards the centre, as in the Shion and Tampopo, and the inflorescence is again termed the *Centripetal* (Fig. 103). In the definite inflorescence with an elongated common peduncle, the flowers open in succession from above downwards; hence it is also called the *Descending* (Fig. 104). When the common peduncle of this inflorescence is shortened, the flowers open from the centre towards the circumference, as in the Yamabōshi *(Cornus kousa)* and Gozentachibana *(C. canadensis)*, and the inflorescence is likewise termed the *Centrifugal.*

KINDS OF THE INFLORESCENCE { Indefinite Inflorescence.
Definite Inflorescence.

Among ascending inflorescences, some bear pedicellate flowers, as in the Kabura and Fuji; while others bear sessile or very short pedicellate flowers, as in the Ōbako and Shidareyanagi. The former kind is called the *Raceme* (Fig. 100) and the latter the *Spike* (Fig. 101).

ASCENDING INFLORESCENCE { Raceme.
Spike.

Fig. 100.

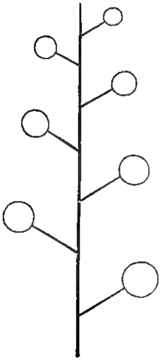

Fig. 100.—Raceme.

Fig. 101.

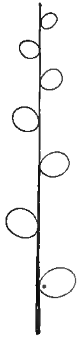

Fig. 101.—Spike.

Fig. 102.

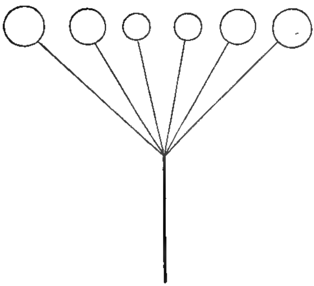

Fig. 102.—Umbel.

Fig. 103.

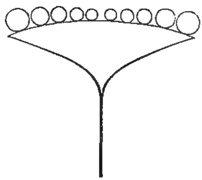

Fig. 103.—Capitulum.

Among centripetal inflorescences, some bear pedicellate flowers, as in the Ninjin and Nodake; while others bear sessile flowers, as in the Shion and Tampopo. The former kind is called the *Umbel* (Fig. 102), and the latter the *Capitulum* (Fig. 103).

Centripetal inflorescence $\begin{cases} \text{Umbel.} \\ \text{Capitulum.} \end{cases}$

Among definite inflorescences, some bear only one flower, as in the Fukujusō and Ichirinsō (see Fig. 98); some bear

FIG. 104.

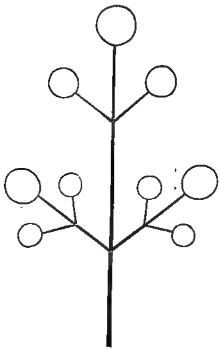

FIG. 104.—Pleiochasial cyme.

numerous flowers the terminal one of which is situated in the centre, as in the Nadeshiko and Kinshibai; and some bear numerous flowers the terminal one of which is situated lowermost, as in the Mōsengoke and Tabirako. The first kind is called the *Simple inflorescence;* the second kind, the *Pleiochasial Cyme* (Fig. 104); and the last, the *False Raceme* or *Sympodial Cyme* (Fig. 105).

DEFINITE INFLORESCENCE { Simple Inflorescence. / Pleiochasial Cyme. / False Raceme.

FIG. 105.

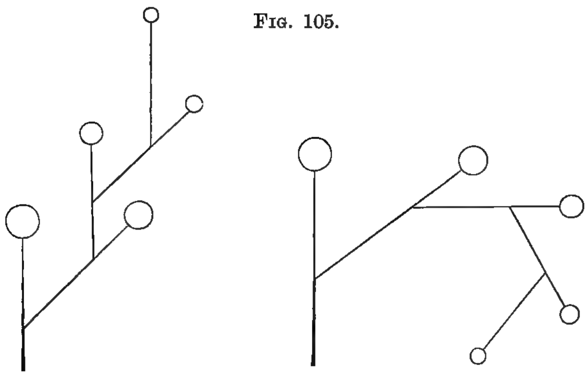

FIG. 105.—False raceme.

All the kinds of inflorescence are represented in the following table.

INFLORESCENCE
- Indefinite Inflorescence
  - Ascending Infl.
    - Raceme.
    - Spike.
  - Centripetal Infl.
    - Umbel.
    - Capitulum.
- Definite Inflorescence
  - Simple Inflorescence.
  - Pleiochasial Cyme.
  - False Raceme.

SPORE-BEARING LEAVES.

The Spore-bearing Leaves are those, which bear minute bodies called the *spores* that answer to seeds. (See Fig. 51.)

KINDS OF SPORE-BEARING LEAVES.—Some spore-bearing leaves may perform only the reproductive function, as those of the Zemmai *(Osmunda regalis)* and Shishigashira *(Lomaria Spicant)* (Fig. 106); while others may perform the nutritive function at the same time, as those of the Nokishinobu (Fig. 51) and Warabi.

SPORE-BEARING LEAF { That with one function. / That with two functions. }

FIG. 106.

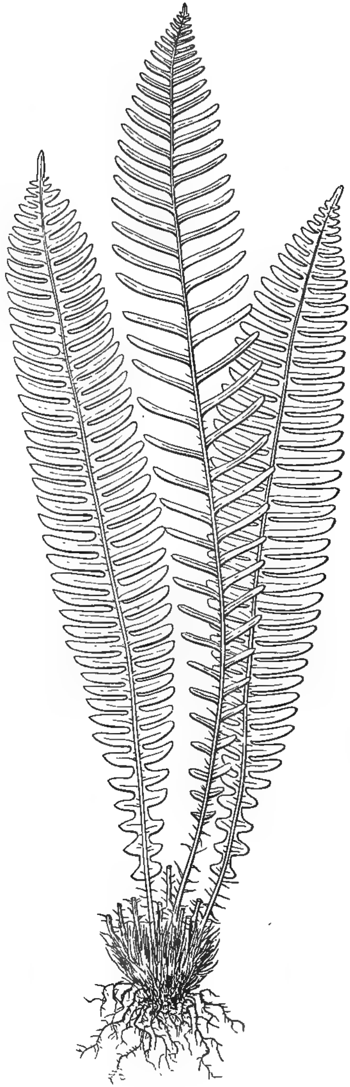

FIG. 106.—Shishigashira *(Lomaria Spicant)*, showing foliage leaves and a spore-bearing one.

SUMMARY.

The *leaf* is that part of a plant, which is always developed laterally on the stem and is usually of a flattened nature.

The *base* of the leaf is its organically lower end.

The *apex* of the leaf is its organically upper end.

The *body* of the leaf is the portion lying between the base and the apex.

The leaf is said to be *coriaceous* when its texture is tough and leathery.

The leaf is said to be *herbaceous* when its texture is weak and soft.

The leaf is said to be *succulent* when its texture is thick and juicy.

The leaf is said to be *membranous* when its texture is thin and flexible.

The leaf is said to be *annual* when it dies the same year in which it is developed.

The leaf is said to be *biennial* when it dies the second year.

The leaf is said to be *perennial* when it lives for many years.

The *aerial leaf* is one which exists exposed to the air.

The *aquatic leaf* is one which exists submersed in water.

The *subterranean leaf* is one which exists buried in the soil.

The *foliage leaf* is one which is always green, mostly flattened, and does not produce reproductive organs.

The *modified leaf* is one which differs from the foliage leaf.

The *lamina* is that part of a foliage leaf, which is usually expanded and situated above other portions.

The *petiole* is that portion of a foliage leaf, which stands between the lamina and the leaf-sheath and is usually semicylindrical.

The *leaf-sheath* is that portion of a foliage leaf, which stands below the petiole and embraces the stem more or less assuming a tubular or sheath-like form.

Stipules are small leafy appendages situated one on each side of the leaf sheath.

Veins are the woody thread-like structures in the lamina.

The *venation* is the mode of veining.

Ribs are large veins proceeding from the base to the apex of a lamina.

The *midrib* is the most prominent central rib.

When veins are distributed to form a kind of network, the venation is said to be *netted-veined.*

When veins are distributed paralled to one another, the venation is said to be *parallel-veined.*

When the netted-veined lamina has but one central rib, the venation is said to be *pinnately veined.*

When the netted-veined lamina has two or more ribs, the venation is said to be *palmately veined.*

When the palmately veined lamina has diverging ribs, the venation is said to be *divergipalmately veined.*

When the palmately veined lamina has converging ribs, the venation is said to be *convergipalmately veined.*

When the parallel-veined lamina has but one rib, the venation is said to be *costal-nerved.*

When the parallel-veined lamina has several ribs, the venation is said to be *basal-nerved.*

When the basal-nerved lamina has diverging ribs, the venation is said to be *flabellinerved.*

When the basal-nerved lamina has converging ribs, the venation is said to be *longitudinal-nerved.*

When the lamina can be divided longitudinally into two similar halves, it is said to be *symmetrical.*

When the lamina can not be divided longitudinally into two similar halves, it is said to be *unsymmetrical.*

When the symmetrical lamina can be divided again by a lateral plane into two similar halves up and down, it is said to be *disymmetrical.*

When the symmetrical lamina can not be divided again by a lateral plane into two similar halves up and down, it is said to be *monosymmetrical.*

When its margins are without notches of any kind, the lamina is said to be *entire.*

When its margins present notches of some kind, the lamina is said to be *uneven.*

When its margins are cut into small indentations, the lamina is said to be *dentate.*

When its margins are cut into divisions extending not more than half way down, the lamina is said to be *lobed.*

When its margins are cut into divisions extending more than half way down, the lamina is said to be *parted.*

When its margins are cut into divisions reaching to the midrib or the base, the lamina is said to be *divided.*

When the apex of the lamina is sharp, it is said to be *acute.*

When the apex of the lamina is rounded, it is said to be *obtuse.*

When the apex of the lamina is abruptly pointed, it is said to be *mucronate.*

When the apex of the lamina is straight as if cut across, it is said to be *truncate.*

When the apex of the lamina is more or less notched, it is said to be *emarginate.*

When the lamina arises immediately from the stem, its insertion is said to be *direet.*

When the lamina is attached to the stem by means of the petiole or the leaf-sheath, its insertion is said to be *indirect.*

When the lamina whose insertion is direct has its margins not at all united except at the point where it is attached to the stem, its insertion is again said to be *free.*

When the lamina whose insertion is direct has its prolonged basilar lobes more or less united with the stem, its insertion is again said to be *adnate.*

When the lamina whose insertion is indirect is attached to the petiole or the leaf-sheath by its base, its insertion is again said to be *basal.*

When the lamina whose insertion is indirect is attached to the petiole by a point more or less within its margins, its insertion is again said to be *intramarginal.*

When leaves are produced singly at each node, they are said to be *scattered.*

When two or more leaves are produced at the same node, they are said to be *polymerous.*

When scattered leaves are produced on a stem with elongated internodes, they are said to be *alternate.*

When scattered leaves are produced on a branch of which the internodes do not elongate, they are said to be *fascicled.*

When two leaves are produced at a node on opposite sides of the stem, they are said to be *opposite.*

When three or more leaves are so produced at a node that the distance between any two adjacent leaves is equal, they are said to be *verticillate.*

The *angular divergence* is the lateral distance between the bases of any two adjacent leaves.

Simple leaves are those which have only one lamina and never more than one articulation at the base.

Compound leaves are those which have two or more laminae or one lamina and two articulations.

Compound leaves with one lamina are said to be *unifoliolate.*

Compound leaves with two or more laminae are said to be *multifoliolate.*

The laminae of compound leaves are termed *leaflets.*

The stalks of leaflets are termed *petiolules.*

The stipules of leaflets are termed *stipels.*

Pinnately compound leaves are those which have their leaflets arranged laterally on a common petiole.

Palmately compound leaves are those which have their leaflets arranged on the top of a common petiole.

Nutritive modified leaves are those which are related either directly or indirectly to the nutrition of the plant to which they belong.

Reproductive modified leaves are those which are related either directly or indirectly to reproduction.

Spines are those nutritive modified leaves or branches which are hard and needle-shaped.

Tendrils are those nutritive modified leaves or branches which are thread-like and capable of coiling spirally.

Cataphyllary leaves are those nutritive modified ones which are small and scaly.

Insectivorous leaves are those nutritive modified ones which are capable of catching insects.

The *flower* is an assemblage of numerous reproductive modified leaves.

Floral leaves are those reproductive modified ones which constitute the flower.

Hypsophyllary leaves are those reproductive modified ones which are situated below a flower or flowers.

Spore-bearing leaves are those reproductive modified ones which bear minute fructifications.

Protective organs of a flower are the floral envelopes consisting of the calyx and the corolla.

Essential organs of a flower are the andrœcium and gynœcium.

The *calyx* is the outermost envelope of the flower and it is composed of flattened usually green organs.

Sepals are those floral leaves which constitute the calyx.

The calyx is said to be *caducous*, when it falls off as the flower expands.

The calyx is said to be *deciduous*, when it falls off with or after the corolla.

The calyx is said to be *persistent*, when it remains after the flowering is over.

The *dialysepalous calyx* is one which consists of distinct sepals.

The *gamosepalous calyx* is one which consists of more or less united sepals.

The *regular dialysepalous calyx* is one which consists of distinct sepals of equal size and like form.

The *irregular dialysepalous calyx* is one which consists of distinct sepals of unequal size and unlike form.

The *regular gamosepalous calyx* is one which consists of more or less united sepals of equal size and like form.

The *irregular gamosepalous calyx* is one which consists of more or less united sepals of unequal size and unlike form.

The *tube* of the gamosepalous calyx is that part where the sepals are united.

The *limb* of the gamosepalous calyx is its free border.

The *throat* of the gamosepalous calyx is the orifice of its tube.

The *corolla* is the inner floral envolope situated within the calyx and it is composed of flattened usually colored organs.

Petals are those floral leaves which constitute the corolla.

The corolla is said to be *caducous*, when it falls off as the flower expands.

The corolla is said to be *deciduous*, when it falls off with or after the calyx.

The corolla is said to be *persistent*, when it remains after the flowering is over.

The *dialypetalous corolla* is one which consists of separate petals.

The *gamopetalous corolla* is one which consists of more or less united petals.

The *regular dialypetalous corolla* is one which consists of separate petals of equal size and like form.

The *irregular dialypetalous corolla* is one which consists of separate petals of unequal size and unlike form.

The *regular gamopetalous corolla* is one which consists of more or less united petals of equal size and like form.

The *irregular gamopetalous corolla* is one which consists of more or less united petals of unequal size and unlike form.

The *limb* of the petal is its expanded portion.

The *claw* of the petal is its stalk-like portion.

The *tube* of the gamopetalous corolla is that part where the petals are united.

The *limb* of the gamopetalous corolla is its free border.

The *throat* of the gamopetalous corolla is the orifice of its tube.

The *andrœcium* is the outer series of the essential organs situated within the corolla, and it is composed of one or more thread-like organs.

Stamens are those floral leaves which constitute the andrœcium.

The *anther* of the stamen is its bag-like portion.

The *filament* of the stamen is its stalk.

The *anther-lobe* is the longitudinal half of an anther.

The *connective* is that portion of a stamen which connects the two anther-lobes.

The *anther-cell* is the cavity of an anther-lobe.

The *pollen* is a term used to denote the minute grains contained in the anther-cell.

The andrœcium is said to be *deciduous*, when it falls off after discharging the pollen.

The andrœcium is said to be *persistent*, when it remains after the flowering is over.

The *apostemonous andrœcium* is one which consists of separate stamens.

The *synstemonous andrœcium* is one which consists of more or less united stamens.

The *simple apostemonous andrœcium* is one which consists of but one fertile stamen.

The *multiple apostemonous andrœcium* is one which consists of two or more separate stamens.

The multiple apostemonous andrœcium is said to be *regular*, when it consists of those stamens which are all of the same length and like form.

The multiple apostemonous andrœcium is said to be *irregular*, when it consists of those stamens which are of different length or unlike form.

The synstemonous andrœcium is said to be *complete*, when its stamens are united into one body.

The synstemonous andrœcium is said to be *incomplete*, when its stamens are united into two or more bodies.

The attachment of the anther is said to be *adnate*, when it is attached on its back throughout its whole length to the filament.

The attachment of the anther is said to be *innate*, when it is attached to the filament by its base.

The attachment of the anther is said to be *versatile*, when it is attached by a point near its centre to the tip of the filament.

When turned inwards, the anther is said to be *introrse*.

When turned outwards, the anther is said to be *extrorse*.

The act of discharging its contained pollen is called the *dehiscence* of the anther.

When the anther splits open longitudinally, its dehiscence is said to be *longitudinal*.

When the anther splits open transversely, its dehiscence is said to be *transverse*.

When the anther opens by holes, its dehiscence is said to be *porous*.

When the anther opens by uplifted valves, its dehiscence is said to be *valvular*.

The *gynœcium* is the inner series of the essential organs occupying the centre of the flower, and it is composed of one or more usually sac-like organs.

Carpels are those floral leaves which constitute the gynœcium.

Gymnospermous carpels are those which are open and scale-like.

The *ovary* is that part of a carpel which is sac-like and contains one or more ovules.

The *ovule* is a small body borne by the placenta and it becomes the seed when the flowering is over.

The *placenta* is that portion of a carpel where the ovules are produced.

The *style* is that portion of a carpel which is situated between the ovary and the stigma.

The *stigma* is the usually dilated rough apex of a carpel.

The cavity of the ovary is termed its *cell*.

The *inner suture* is the line formed by the union of the leaf-margins of a carpel.

The *outer suture* is the line on a carpel corresponding to the midrib.

The *apocarpous gynœcium* is one that consists of one or more separate carpels.

The *syncarpous gynœcium* is one that consists of more or less united carpels.

The *simple apocarpous gynœcium* is one that consists of but one carpel.

The *multiple apocarpous gynœcium* is one that consists of two or more separate carpels.

The *unilocular syncarpous gynœcium* is one that is one-celled.

The *multilocular syncarpous gynœcium* is one that is two or more-celled.

The *fruit* is the ripened gynœcium, and it contains one or more seeds.

The *pericarp* is the fruit-coat.

The *endocarp* is the inner layer of the pericarp.

When thick and very hard the endocarp is termed the *stone*.

The *mesocarp* is the middle layer of the pericarp.

The *exocarp* is the external layer of the pericarp.

Fruits are said to be *deciduous* when they fall off from the stem.

Fruits are said to be *persistent* when they remain permanently on the stem.

Monothalamic fruits are those which are formed from single flowers.

Polythalamic fruits are those which are formed by the combination of several flowers.

Apocarpous fruits are those which consist of one or more separate mature carpels.

Syncarpous fruits are those which consist of more or less united mature carpels.

Simple apocarpous fruits are those which cosist of but one mature carpel.

Multiple apocarpous fruits are those which consist of two or more separate mature carpels.

Dry monothalamic fruits are those which become sap-less when fully ripe.

Fleshy monothalamic fruits are those which are pulpy.

Dry monothalamic fruits are said to be *dehiscent* when they burst open or separate into pieces.

Dry monothalamic fruits are said to be *indehiscent* when they remain closed.

The *follicle* is one of dry apocarpous fruits dehiscing by one suture alone.

The *legume* is one of dry apocarpous fruits dehiscing by both sutures.

The *capsule* is a dry syncarpous fruit which bursts open when fully matures.

The *schizocarp* is a dry syncarpous fruit which separates into its constituent carpels.

The *nut* is an indehiscent dry monothalamic fruit which has a hard pericarp and is usually one-seeded.

The *indehiscent capsule* is an indehiscent dry monothalamic fruit which has not a very hard pericarp and is usually many-seeded.

The *achene* is one of indehiscent dry apocarpous fruits, which is small, seed-like, and is provided with a pericarp separable from the seed or seeds.

The *grain* is one of indehiscent dry apocarpous fruits, which is small, seed-like, and has a thin pericarp consolidated with the seed.

The *drupe* is a fleshy monothalamic fruit which has a very hard endocarp.

The *berry* is a fleshy monothalamic fruit whose pericarp is soft throughout.

The *pepo* is a fleshy monothalamic fruit whose pericarp is soft internally and hard externally.

The *pome* is a fleshy monothalamic fruit whose endocarp is papery, cartilaginous, or bony, and is surrounded by a thick flesh which belongs chiefly to the adnate calyx.

Polythalamic fruits are said to be *dry* when they become sap-less.

Polythalamic fruits are said to be *fleshy* when they are pulpy.

The *seed* is the ripened ovule.

The *testa* is the outer coat of a seed.

The *tegmen* is the inner coat of a seed.

The *kernel* is the body of a seed.

The *embryo* is the rudimentary plantlet formed in a seed.

The *caulicle* is the stem of an embryo.

The *radicle* is the lower end of the caulicle.

The *cotyledon* is the leaf of an embryo.

The *plumule* is the upper end of the caulicle.

The *albumen* is any nutritive substance in the kernel of a seed.

The *monocotyledonous seed* is one whose embryo has but one cotyledon.

The *dicotyledonous seed* is one whose embryo has two cotyledons.

The *polycotyledonous seed* is one whose embryo has more than two cotyledons.

The *petalous flower* is one which has the corolla.

The *apetalous flower* is one which wants the corolla.

The *dialypetalous flower* is one whose corolla is dialypetalous.

The *gamopetalous flower* is one whose corolla is gamopetalous.

The *free dialypetalous flower* is one whose corolla is not united with its calyx.

The *adherent dialypetalous flower* is one whose corolla is more or less united with its calyx.

The free dialypetalous flower is said to be *regular* when its floral envelopes are regular.

The free dialypetalous flower is said to be *irregular* when its floral envelopes are irregular.

The adherent dialypetalous flower is said to be *regular* when its floral envelopes are irregular.

The adherent dialypetalous flower is said to be *irregular* when its floral envelopes are irregular.

The *epigynous gamopetalous flower* is one whose calyx-tube is adherent to the ovary.

The *hypogynous gamopetalous flower* is one whose calyx is free from the ovary.

The epigynous gamopetalous flower is said to be *regular* when its floral envelopes are regular.

The epigynous gamopetalous flower is said to be irregular when its floral envelopes are irregular.

The hypogynous gamopetalous flower is said to be *regular* when its floral envelopes are regular.

The hypogynous gamopetalous flower is said to be *irregular* when its floral envelopes are irregular.

The *monochlamydeous flower* is an apetalous one which has the calyx.

The *achlamydeous flower* is an apetalous one which wants the calyx.

The *bisexual flower* is one which has both the andrœcium and the gynœcium.

The *unisexual flower* is one which has but one essential organ.

The *neutral flower* is one without any essential organ

Bracts are said to be *scattered* when they are singly disposed.

Bracts are said to be *verticillate* when they are disposed in whorls.

The term *inflorescence* denotes the arrangement of the flowers upon the floral axis.

The *indefinite inflorescence* is one in which the lowermost flower expands first.

The *definite inflorescence* is one in which the terminal flower expands first.

The indefinite inflorescence is said to be *ascending* when the flowers are developed on an elongated floral axis.

The indefinite inflorescence is said to be *centripetal* when the flowers are developed on the top of a shortened floral axis.

The *raceme* is an ascending inflorescence with pedicellate flowers.

The *spike* is an ascending inflorescence with sessile or very short pedicellate flowers.

The *umbel* is a centripetal inflorescence with pedicellate flowers.

The *capitulum* is a centripetal inflorescence with sessile flowers.

The *solitary inflorescence* is a definite one with but one terminal flower.

The *pleiochasial cyme* is a general name applied to a definite inflorescence in which the terminal flower expands first.

The *false raceme* is a definite inflorescence arranged like a raceme in which the true terminal flower is disposed lowermost.

Spores are minute globular bodies somewhat corresponding to seeds.

The *spore-bearing leaf with one function* is that which is only related to the formation of spores.

The *spore-bearing leaf with two functions* is that which performs the action of a foliage leaf besides the formation of spores.

CHAPTER IV.

THE BUD.

In the youngest portion of a stem, the internodes are not elongated and the leaves are folded together so as to cover the stem; such a group, that is, the youngest portion covered with rudimentary leaves, is called a *Bud*.

Section 1. KINDS OF THE BUD.

The bud varies according to its position, function, and structure, so that it may be classified in three ways.

1. *KINDS OF THE BUD ACCORDING TO ITS POSITION.*

The bud is developed either at the end of a stem, or laterally upon a stem, root, or leaf; the former kind is said to be *Terminal*, and the latter, *Lateral*. (See Fig. 107.)

FIG. 107.

FIG. 107.—Shoot of the Sakura, showing lateral buds and a terminal one.

KINDS OF THE BUD ACCORDING TO ITS POSITION { Terminal Bud. Lateral Bud.

The terminal buds and those lateral ones, which are developed regularly in the axil of a leaf (as in all the flowering plants), or immediately below or by the side of a leaf (as in many flowerless plants), are said to be *Normal*. (See Fig. 107.) Those lateral buds, which are developed irregularly on older parts of stems, roots, or leaves, are said to be *Adventitious*.

2. *KINDS OF THE BUD ACCORDING TO ITS FUNCTION.*

According to its function, the bud is either *Vegetative* or *Reproductive*.

As the vegetative bud produces foliage-leaves, it is also called the *Leaf-bud*. Some reproductive buds produce flowers; while others, as the globular buds of the Yamanoimo *(Dioscorea japonica)* and Tsukuimo *(D. Batatas)* (Fig. 108), or the bulb-like buds of the Oniyuri and Yamayuri, reproduce new plants when they fall to the ground. Those of the former

kind are called *Flower-buds*, and those of the latter *Fleshy Buds.*

FIG. 108.

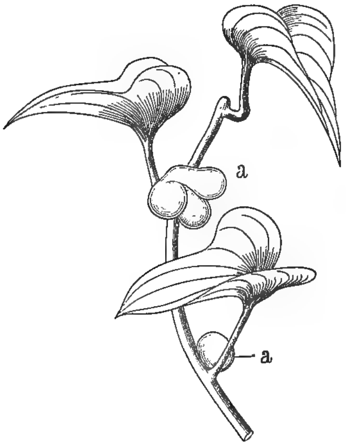

FIG. 108.—Shoot of the Tsukuimo *(Dioscorea Batatas)*, showing fleshy buds (a).

KINDS OF THE BUD ACCORDING TO ITS FUNCTION	Vegetative Bud—Foliage Bud.	
	Reproductive Bud	Flower Bud.
		Fleshy Bud.

3. *KINDS OF THE BUD ACCORDING TO ITS STRUCTURE.*

Some buds are protected by special scales *(Bud-scales)*, as in most trees; while others are not protected by such organs, as in annual herbs. Those of the former kind are said to be *Scaly*, and those of the latter *Naked.*

KINDS OF THE BUD ACCORDING TO ITS STRUCTURE	Scaly Bud.
	Naked Bud.

Section 2. THE PRÆFOLIATION OR VERNATION.

The arrangement of rudimentary leaves in the bud is called the *Præfoliation ;* that of each separate leaf con-

sidered independently is the *Independent Præfoliation;* and that of the leaves in relation to each other is the *Relative Præfoliation.*

PRÆFOLIATION { Independent Præfoliation.
Relative Præfoliation.

As regards the independent præfoliation the leaves are either *Flat* as in the Akamatsu and Momi *(Abies firma)*, *Folded* as in the Mokuren and Momiji, or *Rolled* as in the Hasu and Warabi.

INDEPENDENT PRÆFOLIATION { Flat Præf.
Folded Præf.
Rolled Præf.

As regards the relative præfoliation, the margins of contiguous leaves either touch without overlapping, as the sepals of the Senninsō *(Clematis paniculata)* and Kazakuruma *(C. patens)*, or overlap one another, as the petals of the Fuji and Tsubaki. In the former case the relative præfoliation is said to be *Valvate*, and in the latter *Imbricate.*

RELATIVE PRÆFOLIATION { Valvate Præf.
Imbricate Præf.

Different kinds of præfoliation are represented in the following table.

PRÆFOLIATION {
Independent Præf. { Flat Præf.
Folded Præf.
Rolled Præf.
Relative Præf. ... { Valvate Præf.
Imbricate Præf.

SUMMARY.

The *bud* is an incipient stem with its rudimentary leaves.

The *terminal bud* is one which is developed at the end of a stem.

The *lateral bud* is one which is developed laterally upon a stem, root, or leaf.

The *vegetative bud* is one which produces foliage-leaves.

The *reproductive bud* is one which is related to reproduction.

The *flower-bud* is one which produces floral leaves.

The *fleshy bud* is one which becomes an independent plant when it falls to the ground.

The *scaly but* is one which is protected by special scales.

The *naked bud* is one which is not protected by special scales.

The *præfoliation* is the arrangement of leaves in the bud.

The *independent præfoliation* is the arrangement of each separate leaf in the bud.

The *relative præfoliation* is the arrangement of leaves in relation to each other in the bud.

The independent præfoliation is said to be *flat* when the leaves are not folded in the bud.

The independent præfoliation is said to be *folded* when the leaves are doubled or several times bent.

The independent præfoliation is said to be *rolled* when the leaves are coiled in various ways.

The relative præfoliation is said to be *valvate* when the margins of contiguous leaves touch without overlapping.

The relative præfoliation is said to be *imbricate* when the margins of contiguous leaves overlap one another.

CHAPTER V.

HAIRS.

The Hairs are the protuberances developed from the outermost surface or epidermis of any part of the plant.

Section 1. KINDS OF HAIRS.

Some hairs secrete fluid-substances, as those on the young branches of the Chōshin *(Rosa indica)* (Fig. 109.a) and Tabako; while others do not secrete any substances, as those on the seeds of the Wata *(Gossypium herbaceum)*

FIG. 109.

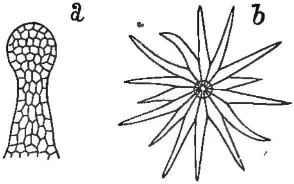

FIG. 109.—a. Glandular hair of the Chōshin (*Rosa indica*). Magnified.
b. Scaly hair of the Akigumi (*Elæagnus umbellata*). Magnified.

and Shidareyanagi. Those of the former kind are said to be *Glandular*, and those of the latter *Eglandular*.

HAIRS { Glandular Hairs.
Eglandular Hairs.

Some eglandular hairs are flattened, as those on the stems and leaves of the Akigumi (*Elæagnus umbellata*) (Fig. 109.b) and Shishigashira (Fig. 106); while others are more or less filiform or needle-shaped, as those on the seeds of the Wata or on the stems of the Tōnasu. Those of the former kind are called *Scales* or *Scaly Hairs*, and those of the latter *Normal Hairs*.

EGLANDULAR HAIRS { Scaly Hairs.
Normal Hairs.

Among normal hairs, some are developed on roots (see Fig. 8), and others on stems or leaves (see Fig. 5). Those of the former kind are called *Root Hairs*, and those of the latter *Shoot Hairs*.

NORMAL HAIRS { Root Hairs.
Shoot Hairs.

Different kinds of hairs are represented in the following table.

HAIRS { Glandular Hairs.
Eglandular Hairs { Scaly Hairs.
Normal Hairs { Root Hairs.
Shoot Hairs.

SUMMARY.

Hairs are protuberances developed from the epidermis of any part.

Glandular hairs are those which secrete fluid-substances.

Eglandular hairs are those which do not secrete any substances.

Scaly hairs are those which are flattened and do not secrete any substances.

Normal hairs are those which are more or less filiform and do not secrete any substances.

Root hairs are those normal ones which are developed on roots.

Shoot hairs are those normal ones which are developed on stems or leaves.

BOOK II.

HISTOLOGICAL BOTANY.

INTRODUCTION.

All parts of all plants, although they are of various sizes and shapes, may, when examined under the microscope, be found to consist of one or more minute sac-like structures. These minute bodies are called *Cells*.

CHAPTER I.

THE CELL.

The Cell is the elementary organ of which the fabric of plants is constructed and is usually more or less sac-like.

Section 1. PARTS OF THE CELL.

If very thin sections are made of the white portions of the leaves of the Negi and examined under the microscope, it will be seen that they are composed of many quadrangular cells, each of which consists of a clear membrane, a layer of granular semifluid substance lying in contact with the inner surface of the latter, a small globular body imbedded in the semifluid substance, and one or more drops of watery fluid. (See Fig. 110.) The membrane is called the *Cell-wall;* the semifluid substance, the *Protoplasm;* the globular body in the latter, the *Nucleus;* and the watery fluid, the *Cell-sap*.

When the cell is young, the protoplasm fills the whole cavity; but in the course of growth small drops of the cell-sap appear and increase gradually in number until they finally coalesce into one large mass, while the protoplasmic layer, on the contrary, becomes thinner and thinner.

FIG. 110.

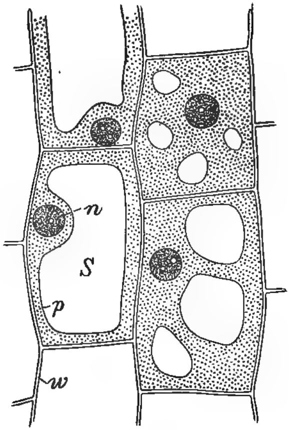

FIG. 110.—Parenchymatous cells from the leaf of the Negi *(Allium fistulosum)*. n Nucleus; p protoplasm; s cell-sap; w cell-wall.

There are some cells which are not provided with cell-walls; these are termed *Primordial Cells*.

PARTS OF THE CELL { Cell-wall. Protoplasm. Nucleus. Cell-sap.

1. *THE CELL-WALL.*

The Cell-wall is the outer membrane of the cell, and consists of cellulose (a carbohydrate), water, and ash-constituents. It is usually colorless and transparent.

Markings.—Sometimes the cell-wall is of uniform thickness throughout, but at other times its thickness varies at different points, so that there result several markings. In the case of isolated cells or of free cell-walls, the markings are produced on the outside of the wall, but in that of united cells they are formed on the inside. In the latter, the markings are sometimes definite; among them some result from hollows made on the internal surface of the cell-wall, and others from prominences on the same surface.

Markings { Those resulting from hollows.
Those resulting from prominences.

Among the markings resulting from hollows, some are caused by true perforations, and others by canals opening only at that end which is turned inwards.

Markings resulting from hollows { Those resulting from true perforations.
Those resulting from canals opening only at one end.

Even the canals opening only at one end become often completely perforated in the course of growth.

Those resulting from true perforations are termed *Sieve Markings* (Fig. 111). There are some cells which have markings much resembling the above but not perforated; these are called *Latticed Cells.*

Fig. 111.

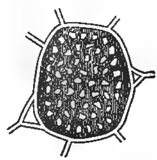

Fig. 111.—Cell with sieve marking from the stem of the Tōnasu (*Cucurbita Pepo*).

Among the markings resulting from canals opening only at one end, some consist of tubular canals and appear as bright spots when seen on the external surface; some of almost hemispherical canals widened at their base and

perforated at their apex, and appear as two concentric circles when seen in front view; and others of transversely elongated canals closely arranged and appear like the rounds of a ladder.

FIG. 112.

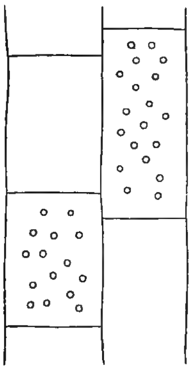

FIG. 112.—Pitted cells from the root of the Tenjikubotan (*Dahlia variabilis*).

FIG. 113.

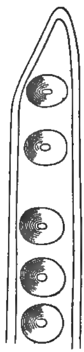

FIG. 113.—Cell with bordered pits from the stem of the Kuromatsu (*Pinus Thunbergii*).

FIG. 114.

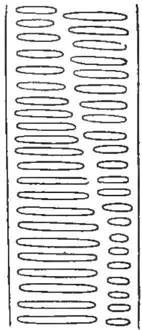

FIG. 114.—Cell with scalariform marking from the rhizome of the Warabi (*Pteris aquilina*).

The markings of the first kind are known as *Pits* (Fig. 112); those of the second kind as *Bordered Pits* (Fig. 113); and those of the last as *Scalariform Markings* (Fig. 114).

MARKINGS RESULTING FROM CANALS OPENING ONLY AT ONE END	Pits. Bordered Pits. Scalariform Markings.

Among the markings resulting from prominences on the inside of the cell-wall, some consist of rings extending around the internal surface; some of spirals; and others of bands united into a network. The markings of the first kind are said to be *Annular* (Fig. 115); those of the second kind, *Spiral* (Fig. 116); and those of the last, *Reticulated* (Fig. 117).

FIG. 115.

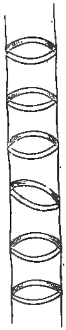

FIG. 115.—Annular vessel from the stem of the Hōsenkwa (*Impatiens Balsamina*).

FIG. 116.

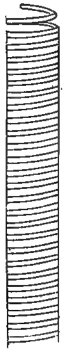

FIG. 116.—Spiral vessel from the stem of the Hōsenkwa.

FIG. 117.

FIG. 117.—Reticulated vessel from the stem of the Hōsenkwa.

MARKINGS RESULTING FROM PROMINENCES
- Annular Markings.
- Spiral Markings.
- Reticulated Markings.

All kinds of markings are represented in the following table.

MARKINGS
- Those resulting from hollows
  - Those resulting from true perforations—Sieve Markings.
  - Those resulting from canals opening only at one end
    - Pits.
    - Bordered Pits.
    - Scalariform Markings.
- Those resulting from prominences
  - Annular Markings.
  - Spiral Markings.
  - Reticulated Markings.

MODIFICATIONS.—If a leaf of the Jinchōge or Aokiba be carefully broken, a thin transparent elastic skin may be removed from the body which can be readily found to consist of hard veins and soft green flesh. The walls of the

cells composing the soft flesh are formed of pure cellulose; but those of the cells composing the skin are so modified that they are more extensible, highly elastic, and almost impermeable to water, and those of the hard cells among the veins are so converted that they are hard, inelastic, and are easily penetrated by water without absorbing much. When modified as in the skin, the cell-wall is said to be *Cuticularized;* and when modified as in the hard cells of veins, it is said to be *Lignified.*

Leaves of the Susuki *(Miscanthus japonicus)* and stems of the Tokusa *(Equisetum hyemale, var. japonicum)* are very hard from the deposition of the salts of silica in considerable quantity in the cell-wall. In this case the cell-wall is said to be *Mineralized.*

All species of *Corallina* (Coral-like Algae) and some of *Chara* become very hard from the deposition of the salts of lime.

The external cell-walls of the sea-weeds, as the Kombu and Funori *(Gloiopeltis coliformis)*, can absorb a large quantity of water and become gelatinous; such cell-walls are said to be *Mucilaginous.*

MODIFIED CELL-WALL	Cuticularized Cell-wall. Lignified Cell-wall. Mineralized Cell-wall. Mucilaginous Cell-wall.

2. *THE PROTOPLASM.*

The Protoplasm consists of albuminous substances, water, and a small proportion of ash-constituents. It is usually a semifluid substance appearing more or less granular from the presence of starch grains, oil-drops, etc.; but in a few cases it appears homogeneous. As the protoplasm is the seat of all living functions it must contain

at different times all the constituents of the organism.

Although the protoplasm is usually a semifluid substance, it sometimes assumes a solid consistence.

3. *THE CELL-SAP.*

The Cell-sap is a watery solution of various substances and usually makes a large sap-cavity within the protoplasm; it also saturates the cell-wall and all the other organic structures of the cell.

The nature of the cell-sap varies in different cells: in some cells large quantities of cane-sugar are present, as in the stems of the Satōkibi *(Saccharum officinarum)* or in the roots of the Tōjisa *(Beta vulgaris)*; in some cells large quantities of grape-sugar are found, as in the fruits of the Budō and Nashi; in some cells inulin exists, as in the roots of the Tampopo and Gobō *(Lappa major)*; in some cells red colouring matter occurs, as in the flowers of the Tsutsuji; and in some blue colouring matter is seen, as in the flowers of the Kazaguruma *(Clematis patens)*.

Section 2. SPECIAL CONTENTS OF THE CELL.

The cell often contains numerous other substances having definite shapes.

If thin sections of the leaves of the Tsubaki are examined under the microscope, there will be seen numerous green granules. These bodies are called *Chlorophyll-corpuscles* (Fig. 118).

If thin sections of the tubers of the Jagataraimo are examined under the microscope, there will be seen numerous whitish granules with concentric layers. These bodies are known as *Starch-grains* (Fig. 120).

If thin sections of the stems of the Shūkaidō are examined under the microscope, there will be seen octahedral bodies

either scattered or aggregated. These are *Crystals* (Fig. 121). of calcium oxalate.

SPECIAL CONTENTS OF THE CELL { Chlorophyll-corpuscles. Starch-grains. Crystals, etc.

If thin sections of oily seeds as those of the Tōgoma (*Ricinus communis*) and Tōnasu are examined under the microscope, there will be seen numerous rounded granules. These are only modified portions of the protoplasm and bear the name of *Aleurone-grains*.

In the cells of the Potato tubers, there are often found cubical bodies of albuminous matter. Although they bear a close resemblance to true crystals, they are readily distinguished from the latter by the fact that they swell up when treated with various reagents. These albuminous bodies are called *Crystalloids*. Crystalloids are also found within some aleurone-grains as those of the Tōgoma and Tōnasu.

If thin sections of the corolla of the Tampopo are examined under the microscope, numerous yellow granules will be seen.

If the root of the Ninjin is examined in the same way, orange-red rectangular plates or rhombs will be found.

1. *CHLOROPHYLL-CORPUSCLES.*

If green leaves are cut into small pieces and put in a vessel containing alcohol, the green colouring matter or *Chlorophyll* is readily extracted by the solvent, and the pieces become whitish. Now if thin sections of these pieces are examined under the microscope, there will be seen colourless corpuscles instead of green ones. These colourless corpuscles are specialized portions of the protoplasm. Each chlorophyll-corpuscle is therefore composed of a colourless granule of the protoplasm distributed by a small quantity of chlorophyll. The corpuscles are mostly spherical, elliptical, or ovate (Fig. 118); but in rare cases they are spiral-shaped as in *Spirogyra* (Fig. 119.a), star-shaped as in *Zygnema* (Fig. 119.b), etc. They often contain minute granules which are the first formed starch-grains.

FIG. 118.

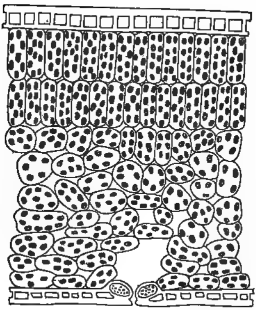

FIG. 118.—Transverse section of the leaf of the Tsubaki *(Camellia japonica)*, showing chlorophyll-corpuscles.

FIG. 119.

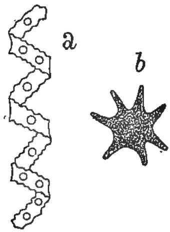

FIG. 119.—Chlorophyll-corpuscles. a Spiral-shaped chlorophyll-corpuscle of a *Spirogyra*; b star-shaped chlorophyll-corpuscle of a *Zygnema*.

2. *STARCH-GRAINS.*

Starch-grains consist of starch, water, and a small proportion of ash-constituents. They have one or more central

FIG. 120.

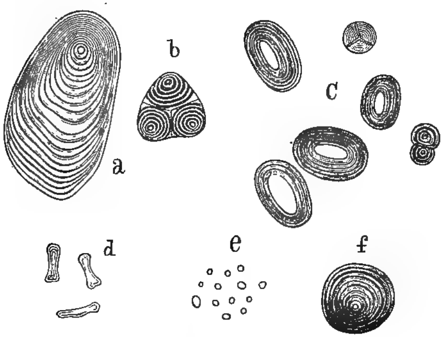

FIG. 120.—Starch grains. a Simple starch grain of the Jagataraimo; b compound starch grain of the same; c starch grains from the seed of the Fujimame *(Dolichos cultratus)*; d starch grains of the Nishikisō *(Euphorbia humifusa)*; e starch grains of the Satoimo; f starch grain of the Satsumaimo *(Ipomœa Batatas)*.

points around each of which concentric layers are disposed; those with but one centre are known as *Simple* (Fig. 120.a), and others with two or more central points *Compound Starch-grains* (Fig. 120.b).

Starch-grains vary in their sizes and shapes in different plants: thus, those of the Jagataraimo are very large and ovate (Fig. 120.a and b); those of the Satoimo are very small and globular (Fig. 120.e); those of the Ingen and Fujimame *(Dolichos cultratus)* (Fig. 120.c) are large and elliptical; those of the Satsumaimo *(Ipomæa Batatas)* (Fig. 120.f) are large and spherical; those of the Nishikisō *(Euphorbia humifusa)* (Fig. 120.d) are small and bone-shaped; and so on.

STARCH-GRAINS { Simple Starch-grains. / Compound Starch-grains.

3. *CRYSTALS.*

Most crystals consist of calcium oxalate, but a few of calcium carbonate.

Crystals of calcium oxalate are either octahedral as in the Shūkaidō (Fig. 121.a), or prismatic as in the Hanashōbu *(Iris lævigata, var. Kæmpferi)* (Fig. 121.c), or acerose as in the Suisen *(Narcissus Tazzeta, var. chinensis)* (Fig. 121.b).

FIG. 121.

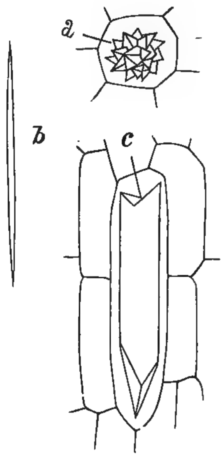

FIG. 121.—Crystal sof calcium exalate.. a Cluster of octahedral crystals of the Shūkaidō; b acerose crystal of the Suisen *(Narcissus Tazzeta, var. chinensis)*; c prismatic crystal of the Hanashōbu *(Iris lævigata, var. Kæmpferi)*.

Section 3. KINDS OF THE CELL.

The form and size of the cell vary greatly, the former being spherical, elliptical, cylindrical, cubical, prismatic, star-shaped, spindle-shaped, etc., and the latter being very large as in *Nitella*, or very minute as in Bacteria. Longitudinal rows of cells often become tulubar by the absorption of their transverse walls.

The cells, which are not much longer than they are broad and have rounded or flattened surfaces, are said to be *Parenchymatous* (Fig. 122); those, which are long and spindle-shaped, *Prosenchymatous* (Fig. 123); and those, which are tubular from the absorption of their transverse walls, *Vascular* (Fig. 115, 116 and 117). The white central portion of the stem of the Yamabuki *(Kerria japonica)* consists of parenchymatous cells; the hemp-fibres consist of prosenchymatous cells; and the small canals in the wood of the Kiri of vascular cells.

FIG. 122.

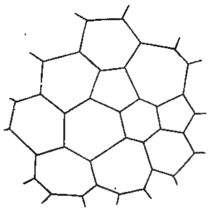

FIG. 123.

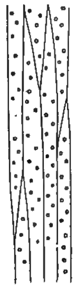

FIG. 122.—Parenchyma from the stem of the Yamabuki *(Kerria japonica)*.

FIG. 123.—Prosenchyma from the stem of the Hōsenkwa.

KINDS OF CELLS { Parenchymatous Cells. / Prosenchymatous Cells. / Vascular cells.

Section 4. FORMATION OF CELLS.

The formation of cells takes place in different ways: cells may be divided into two parts by the formation of new transverse walls, each half becoming a new

cell; the whole or a portion of the protoplasmic contents of a mother cell may become one or more new cells; or the protoplasmic contents of two or more cells may coalesce to form a new cell.

The formation of cells as in the first case is termed the *Cell-division;* as in the second case, the *Interior Cell-formation;* and as in the last, the *Conjugation.* The development of vegetative organs is accomplished by cell-division; pollen-grains, spores of the Nokishinobu, Shishigashira, etc. are produced by interior cell-formation; and spores of *Spirogyra, Zygnema,* etc. are formed by conjugation.

FORMATION OF CELLS	Cell-division. Interior Cell-formation. Conjugation.

SUMMARY.

Cells are the elementary organs of plants and are usually more or less sac-like.

The *cell-wall* is the outer membrane of a cell and consists of cellulose, water, and ash-constituents.

The *sieve markings* of a cell-wall are those which are produced by true perforations.

The *pitted markings* of a cell-wall are those which are produced by numerous canals opening at one end.

The *bordered pits* of a cell-wall are those markings which are produced by hemispherical canals opening at the apex.

The *scalariform markings* of a cell-wall are those which are produced by transverse narrow canals closely disposed one above another.

The *annular markings* of a cell-wall are those which are produced by ring-like interior prominences.

The *spiral markings* of a cell-wall are those which are produced by spiral-shaped interior prominences.

The *reticulated markings* of a cell-wall are those which are produced by net-like interior prominences.

The *cuticularized cell-wall* is one which is so modified that it is extensible, highly elastic, and almost impermeable to water.

The *lignified cell-wall* is one which is so modified that it is hard, inelastic, and is easily penetrated by water.

The *mineralized cell-wall* is one which is hard from the deposition of mineral matters.

The *mucilaginous cell-wall* is one which becomes gelatinous when it absorbs a large quantity of water.

The *protoplasm* is usually a semifluid substance consisting of albuminous matter, water, and a small proportion of ash-constituents.

Primordial cells are those which are destitute of cell-walls.

The *cell-sap* is a watery solution of various substances and usually makes a large sapcavity within the protoplasm; it also saturates the cell-wall and all the other organic structures of the cell.

The *chlorophyll-corpuscle* is a green body which consists of a colourless mass of the protoplasm distributed by a small quantity of a green colouring matter called chlorophyll.

The *starch-grain* is a minute body which has one or more central points surrounded by concentric layers and consists of starch, water, and a small proportion of ash-constituents.

Starch-grains are said to be *simple* when they are provided with but one central point.

Starch-grains are said to be *compound* when they are provided with two or more central points.

Crystals are mostly formed of calcium oxalate and rarely of calcium carbonate.

Parenchymatous cells are those which are not much longer than they are broad and have rounded or flattened connecting surfaces.

Prosenchymatous cells are those which are long and spindle-shaped.

Vascular cells are those which are tubular from the absorption of their transverse walls.

When new cells are formed by the division of a mother cell into two parts, that mode is known as *cell-division*.

When one or more new cells are formed within a mother cell, that mode is known as *interior cell-formation*.

When a single new cell is formed by the coalescence of the protoplasmic contents of two or more cells, that mode is known as *conjugation*.

CHAPTER II.

TISSUES.

Those combinations of cells, which are produced by cell-division and united to each other from the beginning of their existence, are called *Tissues.*

Section 1. KINDS OF TISSUES.

Each tissue may be composed either of parenchymatous cells, as in the white central portion of the stem of the Yamabuki, or of prosenchymatous cells with overlapping ends, as in the hemp-fibres, or of vascular cells, as in the minute canals in the wood of the Kiri. In the first case, the tissue is known as *Parenchyma* (see Fig. 122); in the second, as *Prosenchyma* (see Fig. 123); and in the last, as *Vascular Tissue.*

KINDS OF TISSUES { Parenchyma. / Prosenchyma. / Vascular Tissue.

The parenchyma may consist of soft parenchymatous cells, as in the white central portion of the stem of the Yamabuki, or of hard thick-walled parenchymatous cells, as in the grit of Pears. The former kind may be called the *Soft Parenchyma,* and the latter the *Hard Parenchyma.*

PARENCHYMA { Soft Parenchyma. / Hard Parenchyma.

There is still another kind of parenchyma, which is composed of those cells that are long and mostly prismatic with their walls thickened along the longitudinal angles. It is known as *Collenchyma* and is found in the stems of many plants, as the Tōnasu, Shūkaidō, etc.

The prosenchyma may consist of soft flexible prosenchymatous cells, as in the hemp-fibres, or of hard lignified

prosenchymatous cells, as in the wood of the Akamatsu; the former kind is called the *Bast Prosenchyma*, and the latter the *Woody Prosenchyma.*

PROSENCHYMA	Bast Prosenchyma.
	Woody Prosenchyma.

The vascular tissue may consist of soft vascular cells, as in the inner bark of Dicotyledonous Plants, or of hard vascular cells, as in the wood of common trees; the former are called *Bast Vessels*, and the latter *Woody Vessels* or *Tracheæ.*

VASCULAR TISSUE	Bast Vessels.
	Woody Vessels.

As the bast vessels have thick transverse walls with numerous closely-set perforations (sieve markings), they are also known as *Sieve-vessels* or *Sieve-tubes.* These vessels are filled with protoplasmic contents, and the woody vessels with air or water.

There is another kind of vessels containing a milky or coloured fluid as in the Tampopo; they are called *Laticiferous Vessels.*

All the kinds of tissues are represented in the following table.

KINDS OF TISSUES	Parenchyma.....	Soft Parenchyma.
		Hard Parenchyma.
	Prosenchyma...	Bast Prosenchyma.
		Woody Prosenchyma.
	Vascular tissue.	Bast Vessels.
		Woody Vessels.

Section 2. TISSUE-SYSTEMS.

The lowest multicellular plants are composed of uniform tissues, but in the highest ones their bodies are composed of different tissues which are regularly arranged in particular ways in each plant. Each aggregation of elementary tissues forming a definite portion of the plant-body is called a *Tissue-system.*

1. *KINDS OF TISSUE-SYSTEMS.*

If the petiole of the Ōbako be broken across, tough bundles will be observed, and a thin transparent skin may be easily stripped off from its surface. These bundles are chiefly composed of vessels and prosenchyma, and are called *Fibro-vascular Bundles.* They traverse the plant-body and form the *Fibro-vascular System.* The thin skin covering the plant-body is called the *Epidermal System.* That group of tissues which is situated within the latter and encloses the fibro-vascular bundles, is termed the *Fundamental System.*

$$\text{Kinds of tissue-systems}\begin{cases}\text{Fundamental System.}\\ \text{Fibro-vascular System.}\\ \text{Epidermal System.}\end{cases}$$

The Fundamental System.—This system consists principally of parenchyma from which all the other tissues are derived.

The Fibro-vascular System.—This system consists of prosenchyma, vessels, and a few parenchymatous cells, arranged in bundles which run longitudinally through the plant-body.

Parts of the Fibro-vascular Bundle.—Each fibro-vascular bundle is composed of two portions, an inner and an outer. The inner portion is hard when well developed and consists of woody vessels, woody prosenchyma, and hard parenchyma; and the outer is comparatively soft and consists of bast vessels, bast prosenchyma, and soft parenchyma.

The former portion is called the *Xylen* or *Wood,* and the latter the *Phloëm* or *Bast.*

$$\text{Parts of the fibro-vascular bundle}\begin{cases}\text{Xylem.}\\ \text{Phloëm.}\end{cases}$$

KINDS OF FIBRO-VASCULAR BUNDLES.—Some fibro-vascular bundles possess a layer of generating tissue called the *Cambium* between the xylem and the phloëm, as in the stems of the Sakura and Akamatsu; while others want the cambium, as in the Oniyuri and Nokishinobu. Those of the former kind increase the bulk of the xylem and of the phloëm by the growth of cambial cells, and are said to be *Open;* and those of the latter are incapable of any further growth, and are said to be *Closed.*

KINDS OF FIBRO-VASCULAR BUNDLES IN REGARD TO THEIR GROWTH	Open Fibro-vascular Bundles.
	Closed Fibro-vascular Bundles.

THE EPIDERMAL SYSTEM.—This system consists of more or less modified parenchyma.

PARTS OF THE EPIDERMAL SYSTEM.—When well developed, this system is composed of a membrane, consisting of one or more layers of parenchymatous cells, perforated by numerous openings, and provided with various protuberances. The membrane is called the *Epidermis;* the openings through the latter, *Stomata* (Fig. 124); and the protuberances on the surface, *Hairs.*

FIG. 124.

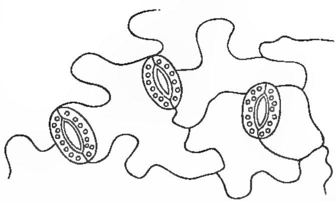

FIG. 124.—Epidermis of the leaf of the Kabura, showing stomata.

The epidermis consists of those cells which are in close juxtaposition without any intercellular spaces except at the points where it is perforated by the stomata. (See Fig. 118.) The upper cell-walls of the epidermis are usually cuticularized and are rendered impermeable to water; but in submersed or very young parts the epidermal cells are not

cuticularized. When roots or stems grow much in thickness, the epidermis is usually ruptured and a new skin is formed from the cortical fundamental tissue.

SUMMARY.

Tissues are those combinations of cells which are produced by cell-division and united to each other from the beginning of their existence.

The *parenchyma* is a tissue composed of parenchymatous cells.

The *prosenchyma* is a tissue composed of prosenchymatous cells.

The *vascular tissue* is one composed of vascular cells.

The *soft parenchyma* is a tissue composed of soft parenchymatous cells.

The *hard parenchyma* is a tissue composed of hard parenchymatous cells.

The *bast prosenchyma* is a tissue composed of soft flexible prosenchymatous cells.

The *woody prosenchyma* is a tissue composed of hard lignified prosenchymatous cells.

Bast vessels are those composed of soft vascular cells.

Woody vessels are those composed of hard vascular cells.

Tissue-systems are aggregations of elementary tissues forming a definite portion of the plant-body.

The *epidermal system* forms the outer skin of the plant-body.

The *epidermis* is a membrane consisting of one or more layers of parenchymatous cells.

Stomata are the openings through the epidermis.

Hairs are the protuberances on the surface of the epidermis.

The *fundamental system* is that group of tissues which is situated within the epidermal system and encloses the fibrovascular system.

The *fibrovascular bundle* is a band chiefly composed of vessels and prosenchyma.

The *xylem* is the hard portion of the fibrovascular bundle.

The *phloëm* is the soft portion of the fibrovascular bundle.

The *fibrovascular system* is composed of fibrovascular bundles.

CHAPTER III.

INTERCELLULAR SPACES.

If the stems of Grasses are cut across, there will be found large cavities extending through whole internodes; and if thin sections of ordinary leaves are examined under the microscope, there will be seen several lacunæ between the cells of the fundamental system. All kinds of the above mentioned lacunæ are termed *Intercellular Spaces.*

Section I. KINDS OF INTERCELLULAR SPACES.

Intercellular spaces vary according to their origin and contents, so that they may be classified in two ways.

1. *KINDS OF INTERCELLULAR SPACES ACCORDING TO THEIR ORIGIN.*

Intercellular spaces may be formed either by a splitting of the common wall of adjacent cells as in the leaves of ordinary plants, or by the rupture of certain cells as in the stems of Grasses.

KINDS OF INTERCELLULAR SPACES ACCORDING TO THEIR ORIGIN	Those formed by a splitting of the common wall of adjacent cells.
	Those formed by the rupture of certain cells.

2. *KINDS OF INTERCELLULAR SPACES ACCORDING TO THEIR CONTENTS.*

Intercellular spaces contain either air as in the stems of Grasses and ordinary leaves, or certain peculiar substances

as the resin-containing lacunæ in the leaves and stems of Pines.

KINDS OF INTERCELLULAR SPACES ACCORDING TO THEIR CONTENTS	Those containing air. Those containing certain peculiar substances.

SUMMARY.

Intercellular spaces are lacunæ between the cells of a tissue.

BOOK III.

PHYSIOLOGICAL BOTANY.

INTRODUCTION.

For the continual existence of plants on the earth, they must first support their own lives for some time and must next reproduce their kinds.

That department relating to the maintenance of their own lives we term *Physiology of Nutrition*, and that relating to reproduction *Physiology of Reproduction*.

CHAPTER I.

PHYSIOLOGY OF NUTRITION.

In order to support their living functions, plants must constantly receive proper food and must convert this into bodily substances, because they consume continually the latter for the performance of every function. These functions are accomplished by the aid of several external forces such as light, temperature, etc.

Section 1. NUTRITION PROPER.

1. *TRANSPIRATION.*

If a tightly closed cylinder containing two or three weighed leaves of the Tōnasu and a dish of dry calcic chloride of known weight be examined after exposing it to the sun for a few hours, it will be found that the leaves will

have withered and lost much weight, and that the salt will have become moistened and much increased in weight. It is clear that what the salt has gained is the water that has been lost by the leaves in the form of vapour. This action is known as *Transpiration*. It is always going on from the surface of all parts of plants which are exposed to the air; above all, leaves are the organs where the greatest loss of water takes place. In adult leaves the watery vapour is principally carried out from the stomata, which regulate transpiration to a great extent by their opening and closing according to different circumstances.

As the cell-walls of the epidermis of submersed plants are not cuticularized, these plants wither rapidly when exposed to the air owing to the evaporation of water from their whole surfaces.

2. *RESPIRATION.*

If some living water plants as *Spirogyra* be put in an air-tight flask filled with water made free from oxygen by boiling, they will perish after a few days.

If a flower-pot with a living plant be put in a closed vessel filled with carbonic acid gas, the plant will die after a few days.

From the preceding experiments it will be understood that oxygen is indispensable to the life of the plant.

If a funnel filled with moist seeds of the Daidzu be inserted into the mouth of a bottle containing a solution of caustic potash, the seeds will gradually commence to germinate, the clear solution will slowly turn whitish, and a rise of temperature may be observed in the germinating seeds.

In the above experiment the potash solution is turned whitish by absorbing the carbonic acid gas which is evolved

by the germinating seeds, and the rise of temperature is caused by the oxidation accompanying germination.

Now it will be seen that plants, like animals, take up oxygen and give off carbonic acid as long as they live, and this process is *Respiration*. In this process heat is always set free in plants as it is in the case of animals; but in plants as the process of heat-production is feeble and other conditions lead to rapid cooling, the rise of temperature is usually insignificant.

3. *ABSORPTION.*

If a flower-pot with a living plant be exposed to the sun without being watered, the plant will begin to droop and wither after a few days. Now if a sufficient quantity of water be given to the plant, it will gradually regain its healthy condition.

If some living land plants with their roots immersed in pure distilled water be kept for a long time, they will gradually become unhealthy and will finally perish.

From the preceding experiments it will be found that plants must absorb water and several other substances for the maintenance of their vitality. It is known from several experiments that the food of plants consists of water, soluble salts, oxygen, and carbonic acid.

Water and soluble salts are absorbed by young roots and root-hairs, oxygen by all living parts, and carbonic acid by all green organs of which leaves are the chief.

Submersed plants may absorb nutritious substances through their whole surfaces.

Some insoluble substances as marble are decomposed by the acid sap, which saturates the cell-walls of the root, and are brought into solution.

4. *CONSTITUENTS OF THE PLANT-FOOD.*

It has been discovered by water culture, which consists in growing plants with their roots immersed in water holding known substances in solution, and analysis, that the elements which are essential to the life of plants are *Carbon*, *Hydrogen*, *Oxygen*, *Nitrogen*, *Sulphur*, *Phosphorus*, *Potassium*, *Calcium*, *Magnesium*, and *Iron*.

Carbon, which is an essential constituent of organic compounds, is absorbed by green plants in combination in the form of the carbonic acid which is found in a small quantity in the atmosphere.

Hydrogen, which is a constituent of every organic compound, is absorbed by all plants in combination usually in the form of water.

Oxygen, which is a constituent of some organic compounds, is absorbed by plants either free, or in combination in the form of water or of salts.

Nitrogen, which is an essential constituent of albuminous substances, is absorbed by plants in combination in the form of nitrates or of compounds of ammonia.

Sulphur, which is a constituent of albuminous substances, Mustard oil, etc., is taken up by plants in the form of sulphates.

Phosphorus, which is a constituent of some organic compounds, is derived from phosphates. It is said that this element bears an important relation to certain metabolic processes of plants.

Potassium, which bears a very important relation to the function of chlorophyll and to the storing-up of carbohydrates, is derived from its salts.

Calcium and *Magnesium*, which are both important for the normal development of plants, are derived from their salts.

Iron, which is absolutely necessary for the formation of chlorophyll, is derived from its different compounds.

Besides the above mentioned elements, *Chlorine*, which is derived from chlorides, is necessary to the normal development of some plants, as the Soba (*Fagopyrum esculentum*); and *Silicon*, which is taken up by plants in the form of silicates or silicic acid, is important in some plants, as the Take, in giving firmness and rigidity to their tissues.

In order to prepare a solution for water-culture, one of the following groups of chemical compounds may be taken.

1.	2.	3.
Distilled water,	Distilled water,	Distilled water,
Potassium nitrate,	Potassium nitrate,	Potassium sulphate,
Calcium sulphate,	Potassium superphosphate,	Calcium nitrate,
Magnesium sulphate,	Magnesium sulphate,	Magnesium phosphate.
Calcium phosphate,	Calcium nitrate,	Ammonium nitrate,
Ferrous sulphate.	Ferrous phosphate,	Ferrous chloride.
	Sodium chloride.	

5. *THE MOVEMENT OF WATER AND SUBSTANCES IN SOLUTION ABSORBED BY THE ROOT.*

If a living branch of the Sakura be cut off and put into a vessel containing a solution of anilin-violet, it will be seen that the colouring-matter rises through the xylem with the water.

If the bark of the Sakura be cut away in the form of a ring around the circumference, the leaves will not wither.

If the stem of the Hechima *(Luffa Petola)* be cut off ten or more inches above the ground, watery fluid will flow out from the cut surface of that portion of the stem which is connected with the root.

From the first and second experiments it will be known that water and substances in solution absorbed by the root are conveyed upward passing through the xylem, in which

the cell-walls are lignified and made to be easily penetrated by water.

From the last experiment it will be seen that the root has itself the function of carrying up the water it has absorbed. This action is called the *Root-pressure.*

As the leaves lose continually water by transpiration, the water absorbed by the root ascends towards them to compensate for the loss; and in the growing portion a fresh supply of water is necessary, and a sufficient quantity is conveyed towards it.

The movement of water is therefore caused by three distinct actions, namely: the root-pressure; transpiration; and growth.

6. *THE MOVEMENT OF GASES.*

In the plant-body, the gases dissolved in water are conveyed by it to the point which is relatively poor in them; and the gases in the intercellular spaces move freely, and communicate with the outer air by means of the stomata.

7. *ASSIMILATION.*

If a water plant as the Sasamo be placed in a glass vessel containing water, which holds carbonic acid in solution, be covered by an inverted glass funnel, whose narrow portion is again covered by an inverted test tube filled with water, and be exposed to sunshine, it will be seen that bubbles of gas are given off from the plant and accumulate within the test tube. If the accumulated gas be tested, it will be found to consist of oxygen.

If water, which does not hold carbonic acid in solution, be used in the above experiment, no bubbles of oxygen gas will be given off.

If green leaves are cut off from the stem during the day

and thin sections of them are examined under the microscope, there will be seen minute starch grains in each chlorophyll-corpuscle.

If green leaves are cut off from the stem during the night and are examined in the same way, there will be found no starch grains in chlorophyll-corpuscles.

From the first experiment it will be seen that green leaves absorb carbonic acid, decompose it by the help of light, and evolve oxygen.

From the second experiment it will be understood that the bubbles of oxygen gas can not be given off without a fresh supply of carbonic acid.

From the third and fourth experiments it will be known that starch grains are formed only during the day in chlorophyll-corpuscles.

Now, from the preceding experiments it is clear that chlorophyll-corpuscles absorb carbonic acid, decompose it by the help of light, give off part of its oxygen, and produce starch grains by combining the residue with the elements of water. Starch grains are indeed the first organic compounds that can be detected under the microscope. This process of the formation of starch grains in chlorophyll-corpuscles is known as *Assimilation.*

8. *CONSTRUCTIVE METABOLISM.*

Starch grains produced in chlorophyll-corpuscles are constantly converted into sugar and removed from the corpuscles; the sugar thus formed may be used up for the formation of cellulose, or albuminous matter combining with other substances, or may be reconverted into starch grains which are stored in different organs for future use.

In short, starch grains formed in chlorophyll-corpuscles

are sources of all the other organic substances of plants, and even the tissues of animals are either directly or indirectly derived from them.

9. *DESTRUCTIVE METABOLISM.*

During the construction of new tissues several compounds are formed as by-products. These are *Tannin*, *Organic Acids*, *Colouring Matters*, *Alkaloids*, *Volatile Oils*, etc.

Old tissues are aften changed into such substances as *Gum Arabic*, *Cherry Gum*, etc. These are the products of degradation which can undergo no further modification in plants.

In the processes of all vital functions, decomposition is an inevitable occurrence, and the evolution of carbonic acid is the result.

10. *EXCRETION.*

In plants, even waste products which are entirely useless to them are mostly retained in their tissues, and only small portions are excreted. The chief excreta of common green plants are all given off in the gaseous form: they are oxygen, carbonic acid, and watery vapour.

Although the majority of waste products are retained in plants, they are gradually got rid of by the detachment of the bark, fruits, etc., in which they are abundantly deposited.

Section 2. EXTERNAL FORCES.

1. *TEMPERATURE.*

If an herbaceous plant as the Kabura be boiled in water, the plant body will become gradually softened and will be finally killed.

If an herbaceous plant as the Satoimo be frozen and be quickly thawed, its vitality will be generally destroyed.

From the preceding experiments it will be seen that common plants can live only within certain limits of temperature. From several experiments it has been assumed that the vital processes of common plants begin at a certain number of degrees above freezing-point and cease at about 50° C.; and that the most favourable conditions of vital activity are generally attained at temperatures from about 25° to 30° C.

2. *LIGHT.*

If the stems of the Udo *(Aralia cordata)* be covered with soil, they will become whitish after several days.

If the seeds of the Daidzu be germinated in complete darkness, the young plants produced will assume a whitish colour.

If the same seeds be germinated in places fully exposed to light, the young plants produced will assume a green colour.

From the preceding experiments it is clear that the formation of chlorophyll is dependent upon light.

The formation of starch in chlorophyll corpuscles, as has been seen, is also dependent upon light.

Light is therefore indispensable to green plants.

In regard to growth, many organs are considerably retarded by light; the stems of many plants are caused by this influence to decline towards the sun.

3. *GRAVITATION.*

If a young plant as the Daidzu planted in a flower-pot be inverted, the apex of the stem will be gradually directed upward and the apex of the root downward.

From the above experiment it will be seen that the root obeys the force of gravitation, while the stem opposes this force.

Gravitation is therefore a force which determines the direction of growing parts.

4. *ELECTRICITY.*

Plants are good conductors of electricity and equalise the difference of the electric tension of earth and air; large trees are therefore often struck by lightning.

Besides the above mentioned forces, wind, various living beings, and others also exercise much influence on plants. Thus, wind may modify the direction of the stem, may disperse fruits and seeds to distant places, may carry the pollen grains of one flower to another, and may perform other actions; and other living beings may disperse fruits and seeds to distant places, may carry pollen-grains, may become the hosts of parasitic plants, and may do other actions.

Section 3. GROWTH.

Growth is brought about by internal processes which enlarge and alter permanently any portion of plants.

A sufficient quantity of raw material and water is first indispensable to growth; and proper temperature is next important.

In the process of growth, new cells are first formed by repeated cell-division; these new cells are next enlarged in size; and they are variously modified in the last. The first stage may be termed *Growing;* the second stage, Elongating; and the last, Fully-developed.

Section 4. IRRITABILITY.

If the leaves of the Nemurigusa *(Mimosa pudica)* be touched by a foreign body, their leaflets will be immediately

drawn together and their main petioles will suddenly bend downward.

If the same plant be observed during the night, it will be seen that its leaves take just the same form as in the case when touched by a foreign body.

This sensitiveness to the action of various external stimuli is known as *Irritability.*

1. *THE IRRITABILITY OF YOUNG ORGANS.*

The organs of plants are most sensitive in their elongating stage to various external stimuli. Thus, young tendrils are soon caused to curve by a slight touch ; and young stems may soon incline towards sunshine

2. *THE IRRITABILITY OF MATURE ORGANS.*

Fully-developed organs are mostly much weakened in their irritability, but a few organs of some plants can perform movements even after they are fully matured. Thus, the leaves of the Nemurigusa change their position day and night, and also when touched; the stamens of the Megi move quickly when they are touched; and the hair-like appendages on the leaves of the Mōsengoke curve inwards when touched by a foreign body.

SUMMARY.

Nutrition is a general term for all the processes of absorption, respiration, transpiration, assimilation, and metabolism.

Transpiration is a process of evaporating water from the surface of the plant-body.

Respiration is a process of absorbing oxygen and evolvlng carbonic acid.

Absorption is a process of diffusing water and substances in solution through the cell-walls of the epidermis into the interior of the plant-body.

Assimilation is a process in which starch grains are formed in chlorophyll-corpuscles.

Metabolism is a general name for all the processes accompanying the construction and the destruction of various tissues.

Growth is a general term for all the processes relating to the permanent enlargement and alterations of various organs.

Irritability is a term denoting the sensitiveness of any organ to the action of external stimuli.

CHAPTER II.

PHYSIOLOGY OF REPRODUCTION.

Some plants, as the Mume, Daidzu, and Ine, usually reproduce their kinds by seeds; while other plants, as the Jagataraimo and Satoimo, usually reproduce their kinds by separating their subterranean stems. The former process is termed the True Reproduction, and the latter the Vegetative Reproduction.

SUMMARY.

True reproduction is a process in wich plants are reproduced by seeds.

Vegetative reproduction is a process in which plants are multiplied by the separation of their own parts.

BOOK IV.

SYSTEMATIC BOTANY.

INTRODUCTION.

Some plants, as the Sakura, Ine, and Akamatsu, produce flowers; while others, as the Warabi, Sugigoke (*Polytrichum commune*), and Kombu, do not produce them. Those of the former kind are termed *Flowering Plants* or *Phanerogamæ*, and those of the latter *Flowerless Plants* or *Cryptogamæ*.

Notwithstanding the vast number of species of plants, they all are either *Phanerogamæ* or *Cryptogamæ*.

$$\text{PLANTS}\begin{cases}\text{Phanerogamæ.}\\ \text{Cryptogamæ.}\end{cases}$$

CHAPTER I.

PHANEROGAMÆ.

In some Phanerogamæ, as the Sakura (Fig. 55) and Ingen (Fig. 76), the ovules are enclosed in an ovary; while in others, as the Akamatsu and Sugi, they are naked having no ovary. The former we term *Angiospermæ*, the latter *Gymnospermæ*.

Phanerogamæ are thus divided into the two groups *Angiospermæ* and *Gymnospermæ*.

$$\text{PHANEROGAMÆ}\begin{cases}\text{Group I. Angiospermæ.}\\ \text{Group II. Gymnospermæ.}\end{cases}$$

FIG. 125.

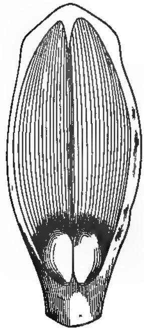

FIG. 125.—Carpellary scale with two seeds from a ripe cone of the Akamatsu.

Group I. ANGIOSPERMÆ.

Some plants of this group, as the Daidzu and Asagao (Fig. 90) have dicotyledonous seeds; while others, as the Ine and Ōmugi (Fig. 89), have monocotyledonous seeds. Those of the former kind are called *Dicotyleæ*, and those of the latter *Monocotyleæ*.

Angiospermæ are thus divided into the two classes *Dicotyleæ* and *Monocotyleæ*.

ANGIOSPERMÆ { Class I. Dicotyleæ.
Class II. Monocotyleæ.

In the plants belonging to Dicotyleæ and Gymnospermæ, the stem is provided with open fibrovascular bundles arranged in circles. If the stem of a Sakura which is several years old be transversely cut, numerous concentric layers will be seen in the xylem. These layers are termed *Annual Rings*. They result from the fact that the cells formed in the spring have a much larger radial diameter than those formed in the autumn.

In the stems of Monocotyleæ and Cryptogamæ, the fibrovascular bundles are irregularly arranged.

Class I. DICOTYLEÆ.

Some plants of this class, as the Kimpōge and Sakura, have dialypetalous flowers ; some, as the Kikyō and Asagao, gamopetalous flowers; and others, as the Jinchōge and Shidareyanagi, apetalous flowers. Those of the first kind are called *Dialypetalæ;* those of the second kind, *Gamopetalæ ;* and those of the last, *Apetalæ.*

Dicotyleæ are thus divided into the three subclasses Dialypetalæ, Gamopetalæ, and Apetalæ.

DICOTYLEÆ	Subclass I. Dialypetalæ.
	Subclass II. Gamopetalæ.
	Subclass III. Apetalæ.

Subclass I. DIALYPETALÆ.

Some plants of this subclass, as the Kimpōge and Kabura (Fig. 54), have free dialypetalous flowers ; while others, as the Sakura (Fig. 55) and Fuji, have adherent dialypetalous flowers. The former we term *Thalamifloræ,* the latter *Calycifloræ.*

Dialypetalæ are thus divided into the two series Thalamifloræ and Calycifloræ.

DIALYPETALÆ	Series I. Thalamifloræ.
	Series II. Calycifloræ.

Subclass II. GAMOPETALÆ.

Some plants of this subclass, as the Hakone-utsugi (Fig. 92) and Tampopo, have epigynous gamopetalous flowers ; while others, as the Asagao and Sagigoke (Fig. 93), have hypogynous gamopetalous flowers. The former we term *Gamopetalæ Epigynæ,* the latter *Gamopetalæ Hypogynæ.*

Gamopetalæ are thus divided into the two series Gamopetalæ Epigynæ and Gamopetalæ Hypogynæ.

GAMOPETALÆ { Series I. Gamopetalæ Epigynæ
Series II. Gamopetalæ Hypogynæ.

Subclass III. APETALÆ.

Some plants of this subclass, as the Tsukubane *(Buckleya lanceolata)* and Kan-aoi *(Asarum Blumei)*, have epigynous flowers; while others, as the Jinchōge and Nawashirogumi, (Fig. 94), have hypogynous flowers.

The former we term *Apetalæ Epigynæ*, the latter *Apetalæ Hypogynæ.*

Apetalæ are thus divided into the two series Apetalæ Fpigynæ and Apetalæ Hypogynæ.

APETALÆ { Series I. Apetalæ Epigynæ.
Series II. Apetalæ Hypogynæ.

Class II. MONOCOTYLEÆ.

Some plants of this class, as the Ayame (see Fig. 69) and Oniyuri (Fig. 126), have showy flowers; while others, as the

FIG. 126.

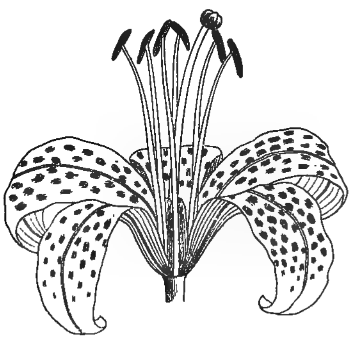

FIG. 126.—Flower of the Oniyuri *(Lilium tigrinum)*.

Shuro and Ine (Fig. 10), have only inconspicuous scaly floral envelopes or even want them. Those of the former

kind are termed *Petaloideæ,* and those of the latter *Nudifloræ.*

Monocotyleæ are thus divided into the two subclasses Petaloideæ and Nudifloræ.

MONOCOTYLEÆ { Subclass I. Petaloideæ.
Subclass II. Nudifloræ.

Subclass I. PETALOIDEÆ.

Some plants of this subclass, as the Ayame (see Fig. 69) and Suisen, have epigynous flowers; while others, as the Oniyuri (Fig. 126) and Tsuyukusa, have hypogynous flowers. Those of the former kind are termed *Petaloideæ Epigynæ,* and those of the latter *Petaloideæ Hypogynæ.*

Petaloideæ are thus divided into the two series Petaloideæ Epigynæ and Petaloideæ Hypogynæ.

PETALOIDEÆ { Series I. Petaloideæ Epigynæ.
Series II. Petaloideæ Hypogynæ.

Subclass II. NUDIFLORÆ.

Some plants of this subclass, as the Shuro and Tennanshō (Fig. 53), have large scattered bracts which cover clusters of flowers; while others, as the Ine (Fig. 10) and Suge, have small scattered bracts. Those of the former kind are termed *Spadicifloræ,* and those of the latter *Glumifloræ.*

Nudifloræ are thus divided into the two series Spadicifloræ and Glumifloræ.

NUDIFLORÆ { Series I. Spadicifloræ.
Series II. Glumifloræ.

General classification of Phanerogamæ are represented in the following table.

PHANEROGAMÆ	Group. I. Angiospermæ	Class I. Dicotyleæ	Subcl. I. Dialypetalæ	Series I. Thalamifloræ.
				Series II. Calycifloræ.
			Subcl. II. Gamopetalæ	Series I. Gamopetalæ Epigynæ.
				Series II. Gamopetalæ Hypogynæ.
			Subcl. III. Apetalæ	Series I. Apetalæ Epigynæ.
				Series II. Apetalæ Hypogynæ.
		Class II. Monocotyleæ	Sebcl. I. Petaloideæ	Series I. Petaloideæ Epigynæ.
				Series II. Petaloideæ Hypogynæ.
			Subcl. II. Nudifloræ	Series I. Spadicifloræ.
				Series II. Glumifloræ.
	Group. II. Gymnospermæ.			

CHAPTER II.

CRYPTOGAMÆ.

Some Cryptogamæ, as the Warabi and Sugina *(Equisetum arvense)* (Fig. 128), have fibrovasculor bundles; some want fibrovascular bundles, having either a stem bearing green leaves as the Sugigoke, or a thalloid body with more or less developed epidermis as the Zenigoke; and others, as the Matsudake and Kombu, want fibrovascular bundles and true epidermis, presenting no differentiation of root, stem, and leaf. Those of the first kind are termed *Pteridophyta;* those of the second kind, *Bryophyta;* and those of the last, *Thallophyta.*

Cryptogamæ are thus divided into the three groups Pteridophyta, Bryophyta, and Thallophyta.

CRYPTOGAMÆ	Group I.	Pteridophyta.
	Group II.	Bryophyta.
	Group III.	Thallophyta.

Group I. PTERIDOPHYTA.

Some plants of this group, as the Warabi and Nokishinobu (Fig. 51), have well developed large leaves; some, as the Hikagenokatsura *(Lycopodium clavatum)* (Fig. 127) and Iwahiba *(Selaginella involvens)*, have small scattered

FIG. 127.

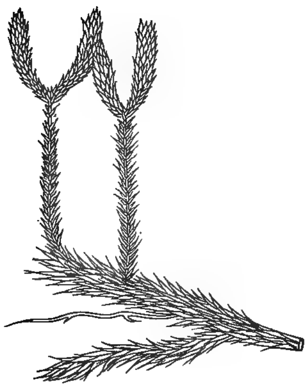

FIG. 127.—Hikagenokatsura (*Lycopodium clavatum*).

FIG. 128.

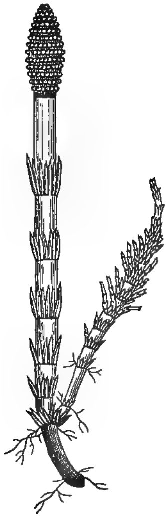

FIG. 128.—Sugina (*Equisetum arvense*).

leaves; and others, as the Tokusa *(Equisetum hyemale, var. japonicum)* and Sugina (Fig. 128), have minute verticillate leaves. Those of the first kind are termed *Filicinæ;* those of the second kind, *Lycopodinæ;* and those of the last, *Equisetinæ.*

Pteridophyta are thus divided into the three classes Filicinæ, Lycopodinæ, and Equisetinæ.

PTERIDOPHYTA	Class I.	Filicinæ.
	Class II.	Lycopodinæ.
	Class III.	Equisetinæ.

Group II. BRYOPHYTA.

Some plants of this group, as the Sugigoke and Kosugigoke *(Pogonatum)* (Fig. 129), have a stem bearing green leaves and multicellular root-hairs; while others bear unicellular root-hairs, having either a thalloid body as the

FIG. 129.

FIG. 129.—Kosugigoke *(Pogonatum sp.)*.

Zenigoke (Fig. 3) or a stem bearing green leaves as the Hime-urokogoke *(Frullania)*. Those of the former kind are called *Musci*, and those of the latter *Hepaticæ*.

Bryophyta are thus divided into the two classes Musci and Hepaticæ.

BRYOPHYTA	Class I.	Musci.
	Class II.	Hepaticæ.

Group III. THALLOPHYTA.

Some plants of this group, as the Matsudake (Fig. 4) and Kabi *(Mucor)*, do not contain chlorophyll; while others, as the Kombu (Fig. 130) and Aonori *(Enteromorpha compressa)*, contain chlorophyll. The former we term *Fungi*, the latter *Algæ*.

FIG. 130.

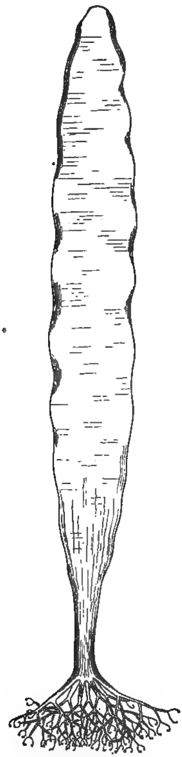

FIG. 130.—Kombu *(Laminaria japonica)*.

Thallophyta are thus divided into the two classes Fungi and Algæ.

THALLOPHYTA	Class I. Fungi.
	Class II. Algæ.

General classification of Cryptogamæ are represented in the following table.

CRYPTOGAMÆ	Group I. Pteridophyta	Class I. Filicinæ.
		Class II. Lycopodinæ.
		Class III. Equisetinæ.
	Group II. Bryophyta	Class I. Musci.
		Class II. Hepaticæ.
	Group III. Thallophyta	Class I. Fungi.
		Class II. Algæ.

SUMMARY.

Phanerogamæ are those plants which produce flowers.

Cryptogamæ are those plants which do not produce flowers.

Angiospermæ are those Phanerogamæ whose ovules are enclosed in an ovary.

Gymnospermæ are those Phanerogamæ whose ovules arc not enclosed in an ovary.

Dicotyleæ are those Angiospermæ which have dicotyledonous seeds.

Monocotyleæ are those Angiospermæ which have monocotyledonous seeds.

Dialypetalæ are those Dicotyleæ which have dialypetalous flowers.

Gamopetalæ are those Dicotyleæ which have gamopetalous flowers.

Apetalæ are those Dicotyleæ which have apetalous flowers.

Thalamifloræ are those Dialypetalæ which have free dialypetalous flowers.

Calycifloræ are those Dialypetalæ which have adherent dialypetalous flowers.

Gamopetalæ Epigynæ are those Gamopetalæ which have epigynous gamopetalous flowers.

Gamopetalæ Hypogynæ are those Gamopetalæ which have hypogynous gamopetalous flowers.

Apetalæ Epigynæ are those Apetalæ which have epigynous apetalous flowers.

Apetalæ Hypogynæ are those Apetalæ which have hypogynous apetalous flowers.

Petaloideæ are those Monocotyleæ which have showy flowers.

Nudifloræ are those Monocotyleæ, which have inconspicuous scaly floral envelopes or want them.

Petaloideæ Epigynæ are those Petaloideæ which have epigynous flowers.

Petaloideæ Hypogynæ are those Petaloideæ which have hypogynous flowers.

Spadicifloræ are those Nudifloræ, which have large scattered bracts covering clusters of flowers.

Glumifloræ are those Nudifloræ which have small scattered bracts.

Pteridophyta are those Cryptogamæ which have fibrovascular bundles.

Bryophyta are those Cryptogamæ, which want fibrovascular bundles having either a stem with green leaves or a thalloid body with more or less developed epidermis.

Thallophyta are those Cryptogamæ, which want fibrovascular bundles and true epidermis, presenting no differentiation of root, stem, and leaf.

Filicinæ are those Pteridophyta which have large well developed leaves.

Lycopodinæ are those Pteridophyta which have small scattered leaves.

Equisetinæ are those Pteridophyta which have small verticillate leaves.

Musci are those Bryophyta which have multicellular root-hairs.

Hepaticæ are those Bryophyta which have unicellular root-hairs.

Fungi are those Thallophyta which do not contain chlorophyll.

Algæ are those Thallophyta which contain chlorophyll.

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